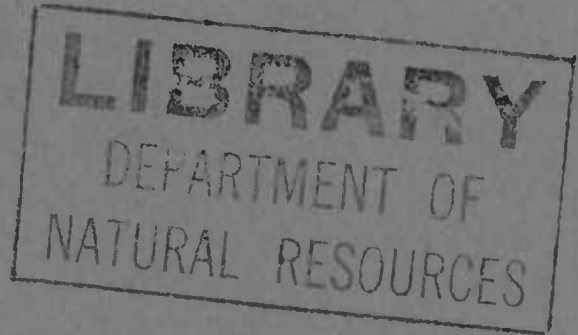


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BALTIMORE REGIONAL ENVIRONMENTAL IMPACT STUDY



Technical Memorandum No. 5
Noise Analysis

Alan M. Voorhees & Associates, Inc. • Environmental Systems Laboratory

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BALTIMORE
REGIONAL
ENVIRONMENTAL
IMPACT
STUDY



TECHNICAL MEMORANDUM NO. 5

NOISE ANALYSIS

10818

Prepared for
THE INTERSTATE DIVISION FOR BALTIMORE CITY

By
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March 1974

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PREFACE

This memorandum, the fifth of a series of seven technical memoranda on the Baltimore Regional Environmental Impact Study (BREIS) prepared for the Interstate Division for Baltimore City (IDBC), describes the assumptions, methodology, and findings for noise analysis.

The other technical memoranda are:

- 1 -- Socioeconomic and Land Use Analysis
- 2 -- Travel Simulation and Traffic Analysis
- 3 -- Air Quality Analysis
- 4 -- Water Resource and Solid Waste Analysis
- 6 -- Analysis of Environmentally Sensitive Areas
- 7 -- Summary Analysis and Evaluation

In addition to IDBC, the Baltimore Regional Planning Council and the Maryland Department of Transportation, including the Mass Transit Administration, have been active participants in the study. Other agencies which have assisted in the project include:

- Maryland Department of Health and Mental Hygiene, Bureau of Air Quality Control
- Maryland Department of Natural Resources
- Maryland Department of State Planning
- Baltimore City, Department of Planning
- Baltimore City, Department of Transit and Traffic
- Baltimore City, Department of Health
- U.S. Federal Highway Administration
- U.S. Environmental Protection Agency

Undertaking the effort was a multidisciplinary team consisting of Alan M. Voorhees & Associates, Inc., with overall responsibility for the study, in conjunction with:

- Environmental Systems Laboratory -- Noise Analysis

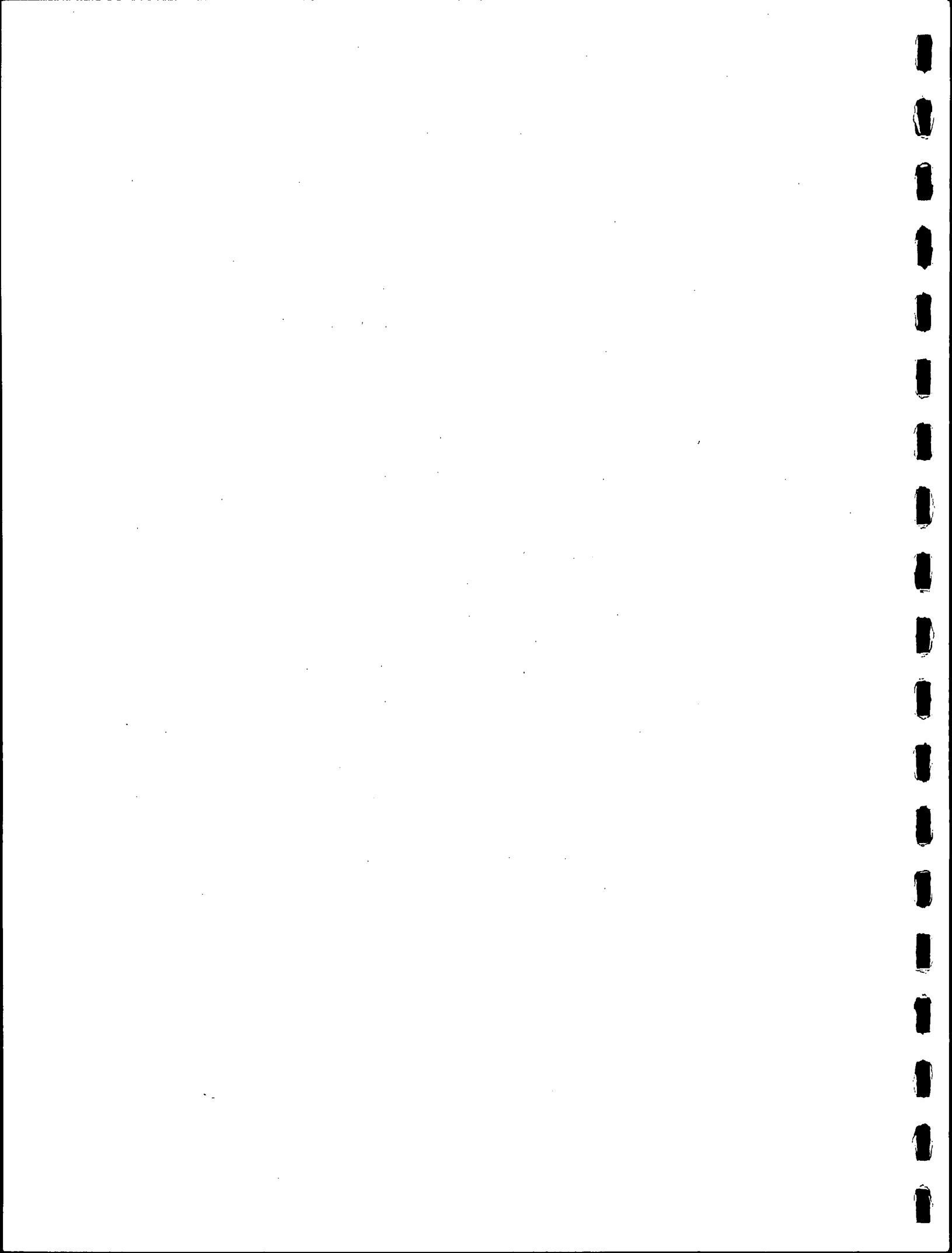
- Jason M. Cortell and Associates, Inc. -- Environmentally Sensitive Areas
- Economics Research Associates -- Economic Analysis
- Dr. David Marks, Resource Analysis, Inc. -- Water Resources & Solid Waste
- Dr. Gerhard Israel, University of Maryland -- Meteorology

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I. BACKGROUND

This study, initiated in the spring of 1973, was the culmination of a series of events related to transportation systems planning and highway construction that had occurred over a number of years in the Baltimore region. The following brief statement outlines the events leading up to the study to provide a context within which the results of the study should be reviewed.

The highway system which is the subject of this study was defined in a previous comprehensive study of the Interstate plan in Baltimore by Urban Design Concepts Associates, (1) as well as in several other planning studies that preceded it. (2) This system, shown in Figure I-1, is known as the 3-A system. It was adopted in 1969 by the Baltimore Planning Commission and subsequently approved by the Regional Planning Council (RPC) for inclusion in the General Development Plan. The 3-A system consists of several segments of I-70N, I-83, I-95, the I-395 and I-170 spurs, and City Boulevard, an arterial link not on the Federal Interstate System. In the spring of 1973, the following portions of the system were complete:

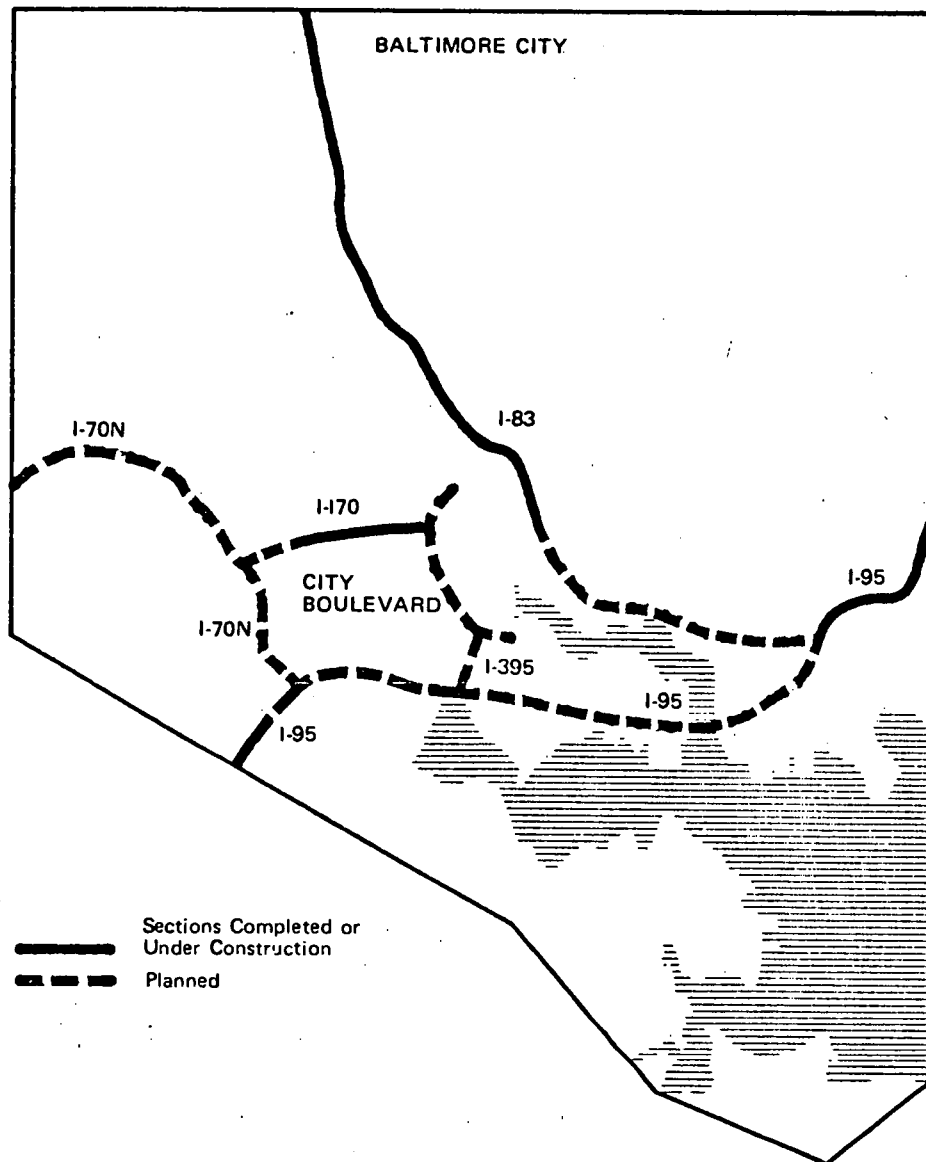
- I-70N was constructed to the City line
- I-95 was constructed to Caton Avenue just inside the City line on the south and was under construction on the east side in the vicinity of the Harbor Tunnel Thruway to O'Donnell Street
- I-83 (Jones Falls Expressway) was constructed on the north to a point near Eager Street.

In addition, several other segments had received design approval.

With the passage of the National Environmental Policy Act of 1969 (NEPA), many of the environmental concerns which had been expressed by various groups in the Baltimore region received official recognition. Section 102(2)(C) of this act requires a detailed statement for any proposed federal action affecting the environment, including:

- The environmental impact of the proposed action
- Any adverse environmental effects which cannot be avoided should the proposal be implemented

Figure I-1. Baltimore 3A System



- The relationships between the local short-term uses of man's environment and the maintenance of long-term productivity
- Any irreversible and irretrievable commitments of resources that would be involved in the proposed action should it be implemented

For federal highway construction, these requirements were reinforced by provisions of the Federal-aid Highway Act of 1970 (Section 136), the Department of Transportation Act as amended (Section 4(f)), the Clean Air Act Amendments of 1970, and the Historic Preservation Act of 1966. The Federal Highway Administration (FHWA), in its Policy and Procedures Memorandum 90-1, has directed that these provisions be fulfilled by highway agencies for each highway construction project.

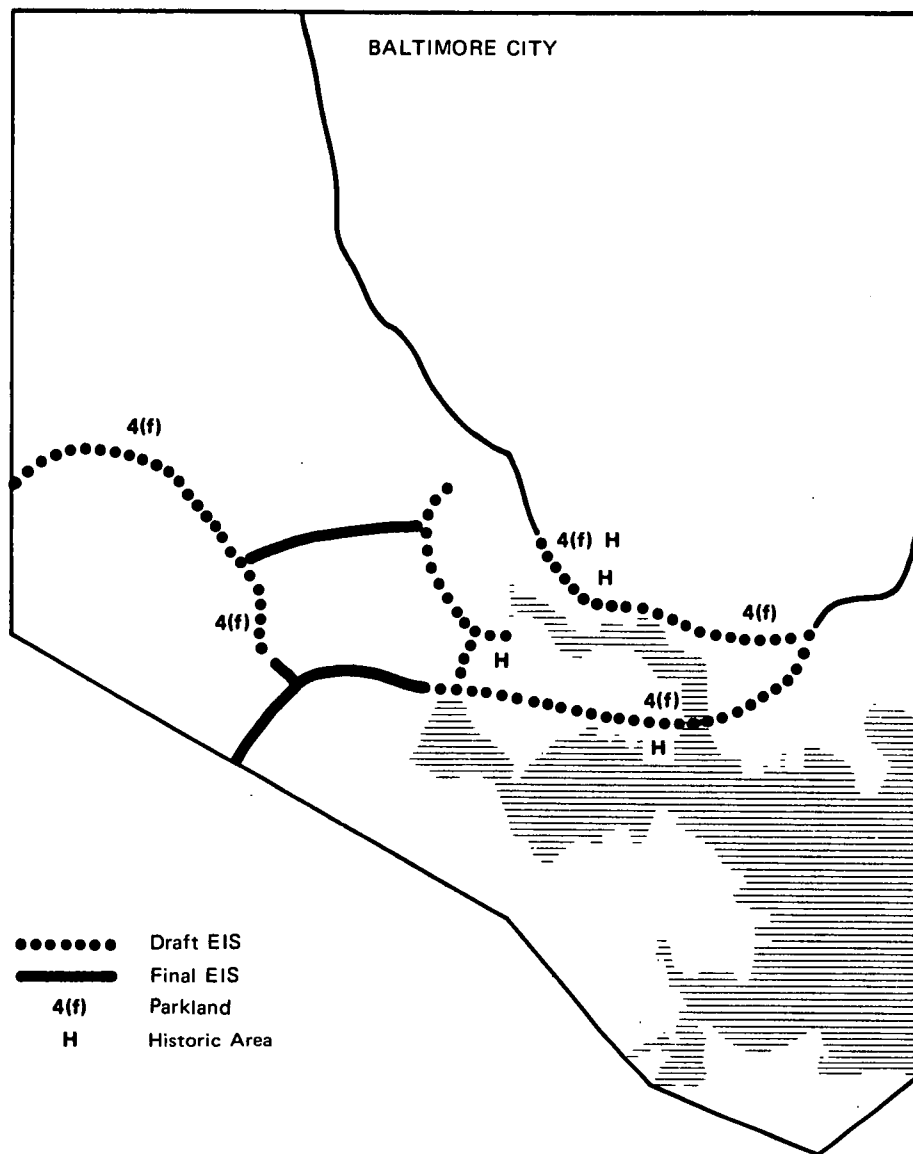
In response to these new requirements, the Maryland Department of Transportation (MdDOT) has submitted a draft environmental impact statement (EIS) for each segment of the 3-A system as it reached the location and design approval stage. The segments of the 3-A system for which environmental impact statements have been prepared are shown in Figure I-2.

However, a citizen suit was filed in 1972 against the U.S. Department of Transportation (Movement Against Destruction (MAD) vs. Volpe) charging that the 3-A system as a whole represented a significant federal action and that a regional environmental impact statement should be filed in addition to separate statements for each facility. Another question, relating to the Franklin-Mulberry Corridor (I-170) asserted that the EIS process had not been sufficient to meet NEPA and other federal requirements. Rights-of-way had been purchased in this corridor, and the City would be required to return over \$5 million to FHWA if construction on this segment did not begin by June 30, 1973.

Two other cases (Sierra Club, Inc. vs. Volpe and Lukowski vs. Volpe), also questioning the adequacy of the EIS process, were then pending in the courts. It was agreed that the relevant portions of all these cases would be heard concurrently on April 16, 1973.

As a result of this hearing, the court found on June 22, 1973 that "the applicable law does not require that an environmental impact statement be prepared for the 3-A system as such." Further, "components of the 3-A system are not necessarily so interdependent as to require the construction of all the 3-A system or none of it." The court continued that:

Figure I-2. Environmental Impact Statements (EIS) on 3A System



It may be wise for the city, state and federal authorities to prepare in the near future a statement which considers those environmental impacts that should be determined with respect to the entire configuration, or major portions thereof. Such a statement would be included in one or more of the EISs which will have to be prepared in the future for other sections of the highways in the 3-A system and which will, of course, also include and consider those environmental impacts that should properly be determined section by section or road by road. (3)

As a result of this decision, construction began in the disputed section of the Franklin-Mulberry Corridor on June 22, 1973.

Concurrent with the legal contest, the U.S. Environmental Protection Agency (EPA) was stressing the need for a regional environmental analysis for the 3-A system. In September 1972, based on a series of discussions, a consensus agreement between EPA and FHWA was reached. This agreement provided in part:

- For all remaining segments of the 3-A system under environmental review neither PS&E (plans, specifications and estimates) approval nor further right-of-way approval would be granted by FHWA until a regional impact consideration statement was prepared and circulated to FHWA, EPA, the U.S. Department of Transportation, and the Maryland Department of Health and Mental Hygiene, Bureau of Air Quality Control (BAQC).
- That the regional impact consideration statement will address those regional issues, identified by EPA in its various reviews, that cannot be addressed on a project basis and will include as a minimum:
 1. Cumulative (regional) air pollution impact of the various stages of completion of the currently envisioned 3-A system (including the MTA system) in the years 1978, 1980, 1985, and 1990.
 2. A detailed discussion of possible modifications to the proposed system to mitigate air pollution problems. The effect of these changes on land use and local traffic patterns should be discussed. These modifications should include the options of:

- Increased highway access to the MTA system
- Impact of elimination of various segments of the 3-A system
- Optimization of construction scheduling to minimize saturation of local street systems
- Impact of the no-build-alternative

It is in response to these actions and the desire of regional and local agencies to understand the socioeconomic, traffic, and environmental implications of the 3-A plan that the study presented in this series of reports is directed.

STUDY ORGANIZATION AND PLAN

The study was programmed for completion in approximately six months. The conduct of the study, under the direction of the Interstate Division for Baltimore City (IDBC), was a joint effort by the consultant team and other regional and local agencies. Some of the work for this study was accomplished by RPC and MdDOT, with assistance from AMV, as part of the "3-C" (cooperative, comprehensive, and continuing) planning process element of the Unified Transportation Planning Program in the Baltimore region.

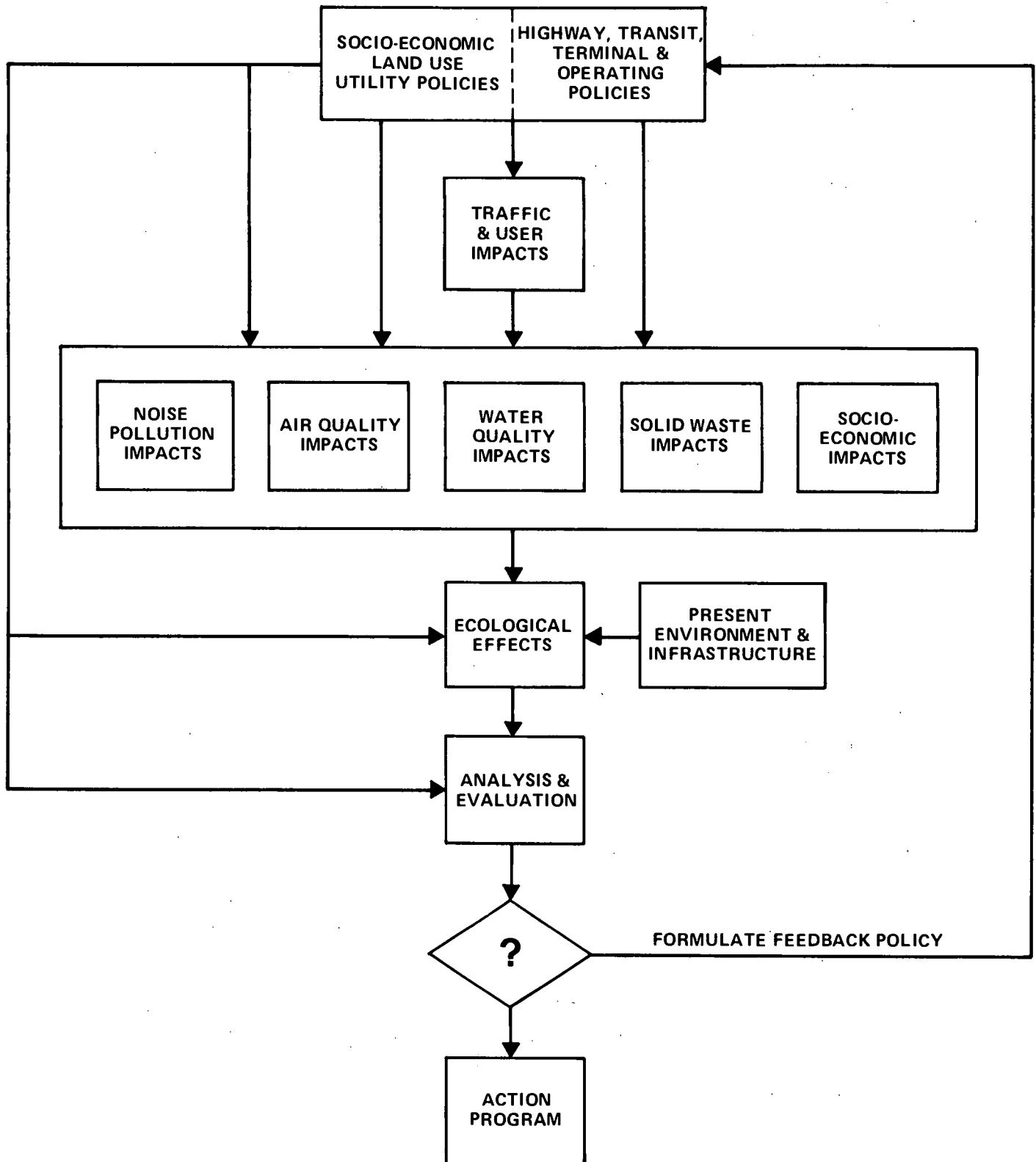
The study process outlined in Figure I-3 was directed toward the measurement of several regional environmental features through which the examination of the estimated future impacts that the 3-A system would have on:

- Socioeconomic and land use factors
- Traffic and travel demand
- Air quality
- Noise pollution
- Water resources and solid waste
- Ecologically sensitive areas

To provide a basis for determining the extent to which future environmental conditions were related to the 3-A system as opposed to other factors, such as growth in population, the environmental consequences of several alternative transportation systems, including a "no-build" option, were also studied. These alternatives were devised jointly by the various agencies associated with the study, both as alternatives to the 3-A system and as a basis for determining the regional environmental consequences of major

Figure I-3.

BREIS-PROCESS FOR EVALUATION OF ALTERNATIVES



components of that system. These alternatives were selected to isolate various conditions and assess their impact on the region. One of the significant features of this procedure is that land use and socioeconomic activity policies were varied separately for each transportation alternative studied. This permitted an assessment of the predicted effects of changes in urbanization due to transportation policy on the region and demonstrates the interrelationships between transportation and land use.

The study area includes the jurisdictions represented in the RPC -- Baltimore City, and Baltimore, Anne Arundel, Carroll, Harford, and Howard Counties, as shown in Figure I-4. A comprehensive General Development Plan (GDP), which includes a land use pattern element, was adopted for the region in December 1972. It includes the full 3-A system, numerous freeways and other highways outside the City of Baltimore, and a regional rapid transit system comprised of six major lines. This plan serves as one alternative and is the basis for the examination of alternative transportation and land use assumptions for future years.

DESCRIPTION OF ALTERNATIVES

The transportation and land-use alternatives studied consist of three systems for 1980 and four systems for 1995. These alternative systems are shown in Table I-1 and are briefly described below. A tear-out copy of Table I-1, which can be used as a reference while reading this report, can be found at the end of Chapter I.

Originally the study plan included a 1978 system for analysis based on the premise that all of the 3-A system except the Fort McHenry bypass could be completed by 1978; however, since the Phase I rapid transit lines would not be completed until 1980 and since revisions to contemplated construction schedules by IDBC have made the 1978 date meaningless, this was eliminated in favor of analyzing the no-build system in 1995. RPC and MdDOT will continue the analysis for 1978, if necessary.

Phase I rapid transit will consist of 28 miles of rail running northwest to Owings Mills and south to Glen Burnie. All 1980 alternatives include the Phase I rapid transit; all 1995 alternatives are based on the GDP and include the full 6-legged rapid transit system, as well as an augmented bus system.

The differences among the 1980 alternatives are related to the 3-A system-- in Alternative 3 the full 3-A system is assumed to be completed; in Alternative 4 the 3-A system will be completed except for the Fort McHenry Crossing; and only existing Interstate facilities or those under construction were

Figure I-4. Study Area—Baltimore Regional Environmental Impact Study



Table I-1.

**TRANSPORTATION ALTERNATIVES FOR BALTIMORE
REGIONAL ENVIRONMENTAL IMPACT STUDY**

ALTERNATIVE	YEAR	HIGHWAY ASSUMPTION		RAPID TRANSIT ASSUMPTION
		3-A INTERSTATE	OTHER HIGHWAYS	
1	1970	Existing	Existing	None
*2	1978	Existing and Programmed	Existing and Programmed	Phase I
3	1980	Complete	Existing and Programmed	Phase I
4	1980	Partial	Existing and Programmed	Phase I
5	1980	Existing and under construction	Existing and Programmed	Phase I
6	1995	Complete	GDP	GDP
7	1995	Existing and under construction	GDP	GDP
8	1995	Complete	Existing and under construction	GDP
9	1995	Existing and under construction	Existing and under construction	GDP

*Eliminated in favor of Alternative 9.

assumed in Alternative 5. Other programmed highway improvements which were assumed to be operational by 1980 include the Northwest Freeway and the Outer Harbor Crossing which is part of the Baltimore Beltway (I-695). The John F. Kennedy Expressway (I-95) northeast of Baltimore has been widened since 1970.

In 1995, the differences concern not only the 3-A, but also other planned GDP highway improvements. Examples include, in addition to those completed in 1980, construction of the Perring Freeway northeast of the City; upgrading and extension of U.S. 29 and the southern portion of Maryland Route 3; and widening of other facilities including U.S. 40, the Baltimore-Washington Parkway, U.S. Route 1, the Arundel Freeway, and Hilton Street in Baltimore City.

Alternative 6 includes the completed 3-A system and other GDP highway improvements while Alternative 7 includes GDP improvements with the exception of the 3-A system. Alternative 8 includes the 3-A, but no other GDP highway improvements except those under construction. Alternative 9 does not include either the 3-A or other GDP highway improvements except those under construction.

GENERAL ASSUMPTIONS AND DEFINITIONS

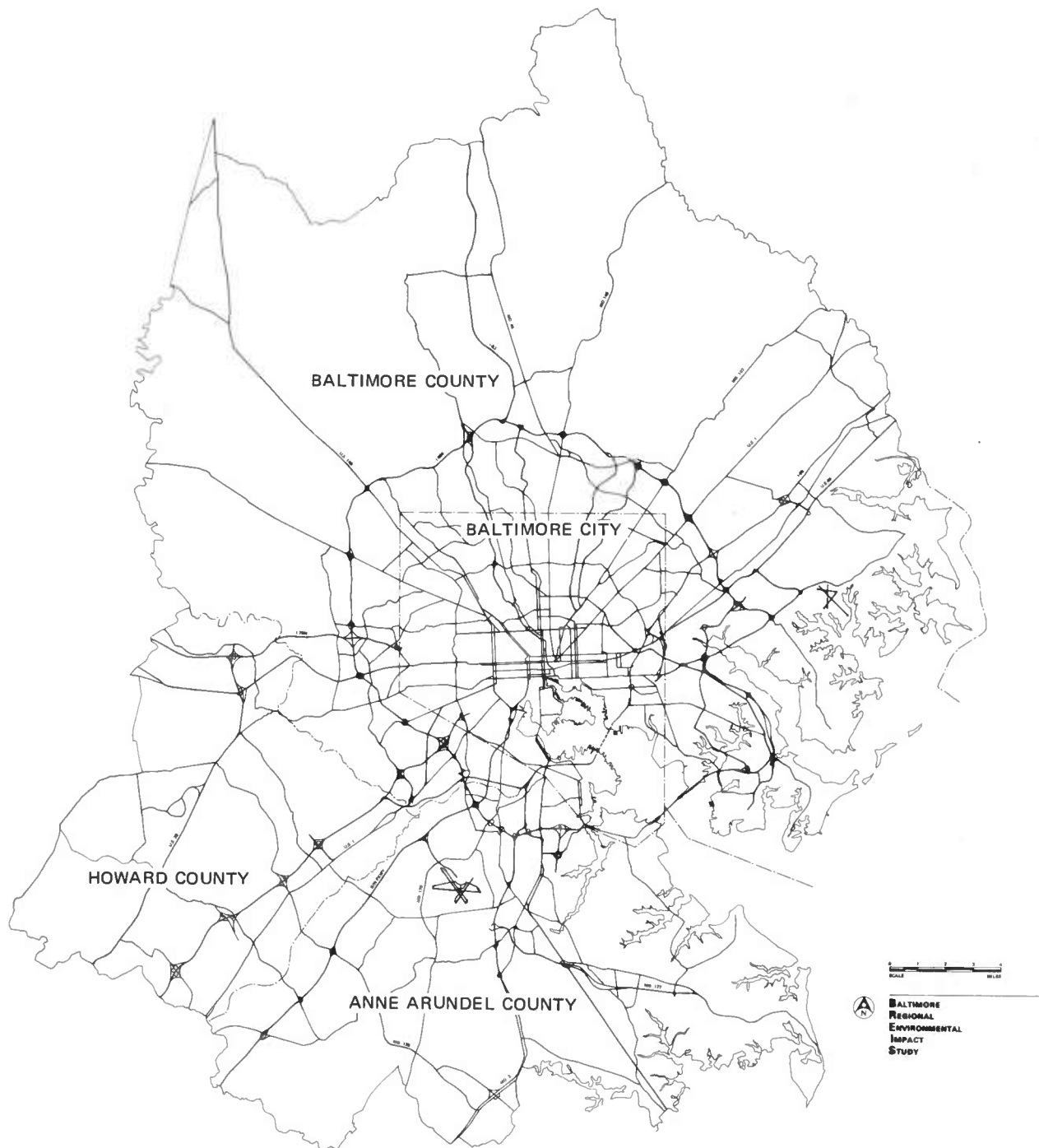
A number of assumptions have been made jointly by IDBC and the study team throughout the conduct of this study. Those which relate to specific areas are stated and described in the appropriate technical memorandum. One general assumption is that no special transportation control strategies to reduce air pollution, except Federal Motor Vehicle Controls, are represented in any of the alternatives. At the time of the study no State Implementation Plan to reduce mobile source emissions in the Baltimore region had been formally adopted.

For purposes of analysis the region was divided into 94 Regional Planning Districts (RPDs) and the urbanized area was further divided into 498 transportation zones. The transportation analysis is concentrated within the area comprising the 1964 Baltimore Metropolitan Area Transportation Study (BMATS) as shown in Figure I-5.

STUDY RESULTS

The purpose for the Baltimore Regional Environmental Impact Study has been outlined in the preceding discussion. The role of the study in the region has been stated in the U.S. District Court decision of June 22, 1973 (3):

Figure I-5. BMATS Study Area



The study has developed into a future planning tool for RPC and Maryland DOT. Many state agencies, such as State Planning, State Health, City Planning and City Health, in addition to RPC and Maryland DOT, will have a use for the study when completed. It will be a data base and data resource document that can be used for possibly setting future transportation policies and other policies within the Baltimore Metropolitan region.

The study results will be framed to answer the following broad questions:

- What were the regional environmental problems in 1970?
- Will there be regional environmental problems in the short-term (1980) with the 3-A system? Without the 3-A system?
- Will there be regional environmental problems in the long-term (1995) with the 3-A system? Without the 3-A system? With the GDP highway plan?
- What are the regional differences between alternatives?
- What regional effects can be attributed to the 3-A system?
- Is there a need for further study?

LIST OF REFERENCES -- CHAPTER I

1. Urban Design Concept Associates, "Transportation, Environmental, and Cost Summary -- An Evaluation of Three Concepts for Expressway Routes in Baltimore City," 1968. (Supported by a series of reports on route segments).
2. Wilbur Smith and Associates, "Baltimore Metropolitan Area Transportation Study," 1964.

Alan M. Voorhees & Associates, Inc., "Travel Forecasting and Patronage Estimates for Baltimore Region Rapid Transit System," July, 1968.

Alan M. Voorhees & Associates, Inc., "Update of Patronage, Revenue, and Operating Costs for Phase I, Baltimore Rapid Transit System," January, 1971.

3. Movement Against Destruction v. Volpe, Civil N. 72-1041-M (D. Md., filed June 22, 1973).

TRANSPORTATION ALTERNATIVES FOR BALTIMORE REGIONAL ENVIRONMENTAL IMPACT STUDY

ALTERNATIVE	YEAR	HIGHWAY ASSUMPTION		RAPID TRANSIT ASSUMPTION
		3-A INTERSTATE	OTHER HIGHWAYS	
1	1970	Existing	Existing	None
*2	1978	Existing and Programmed	Existing and Programmed	Phase I
3	1980	Complete	Existing and Programmed	Phase I
4	1980	Partial	Existing and Programmed	Phase I
5	1980	Existing and under construction	Existing and Programmed	Phase I
6	1995	Complete	GDP	GDP
7	1995	Existing and under construction	GDP	GDP
8	1995	Complete	Existing and under construction	GDP
9	1995	Existing and under construction	Existing and under construction	GDP

*Eliminated in favor of Alternative 9.

II. OVERVIEW

The goal of the noise study conducted in the Baltimore region was to develop an objective index of community noise impact and to employ this index to rank the relative impact among the alternative Baltimore Regional Environmental Impact Study (BREIS) transportation and land use plans. In addition, abatement measures which will significantly reduce noise impact have been defined.

The first step was to determine a working definition of noise. Noise has been defined as unwanted sounds which exceed the levels specified by the Federal Highway Administration in their recent memorandum (PPM-90-2).

Two community noise impact indices have been developed. One is the number of hours per day an average individual in a given geographical area and activity is exposed to noise levels above a certain standard, i.e., the per capita community noise dosage for a given land use. The second index is the total number of hours per day all individuals in a given geographical area and activity are exposed to noise levels above a certain standard, i.e., the total person-hour community noise dosage.

The selected geographical areas are based on the political jurisdictions in the BREIS study area--Baltimore City and the four outlying counties. The activities are based on four land use classes: residential, commercial, institutional, and industrial.

The noise impact indices (i.e., the community dosages) were calculated using a computer program which accepts as input the land use and traffic data generated by the BREIS study (see Technical Memoranda No. 1 and No. 2), and uses a sound propagation program to predict the extent of noise impact. The sound propagation program was validated by extensive field tests in the study area and is consistent with the recommended prediction methodology as specified by the Federal Highway Administration Report 117. The contribution of additional sound from the planned rail transit system was considered; the limited information available at this time indicates that a relatively minor contribution to the community noise levels will be produced directly by the rail transit system.

Independent of the relative ranking, the analysis indicates several important characteristics of community noise dosage in the study area. The primary source of noise at most locations in the study area is from roadway vehicles. The present and projected per capita residential noise dosage inside

Baltimore City is an order of magnitude greater than that in the rest of the Baltimore Metropolitan Area Transportation Study (BMATS) area, whereas the institutional, industrial, and commercial per capita dosages are comparable throughout the entire BMATS area. The proximity of these latter land use categories to roadways both inside and outside Baltimore City accounts for this similarity, while the dense build-up in the City places many residential areas near roadways.

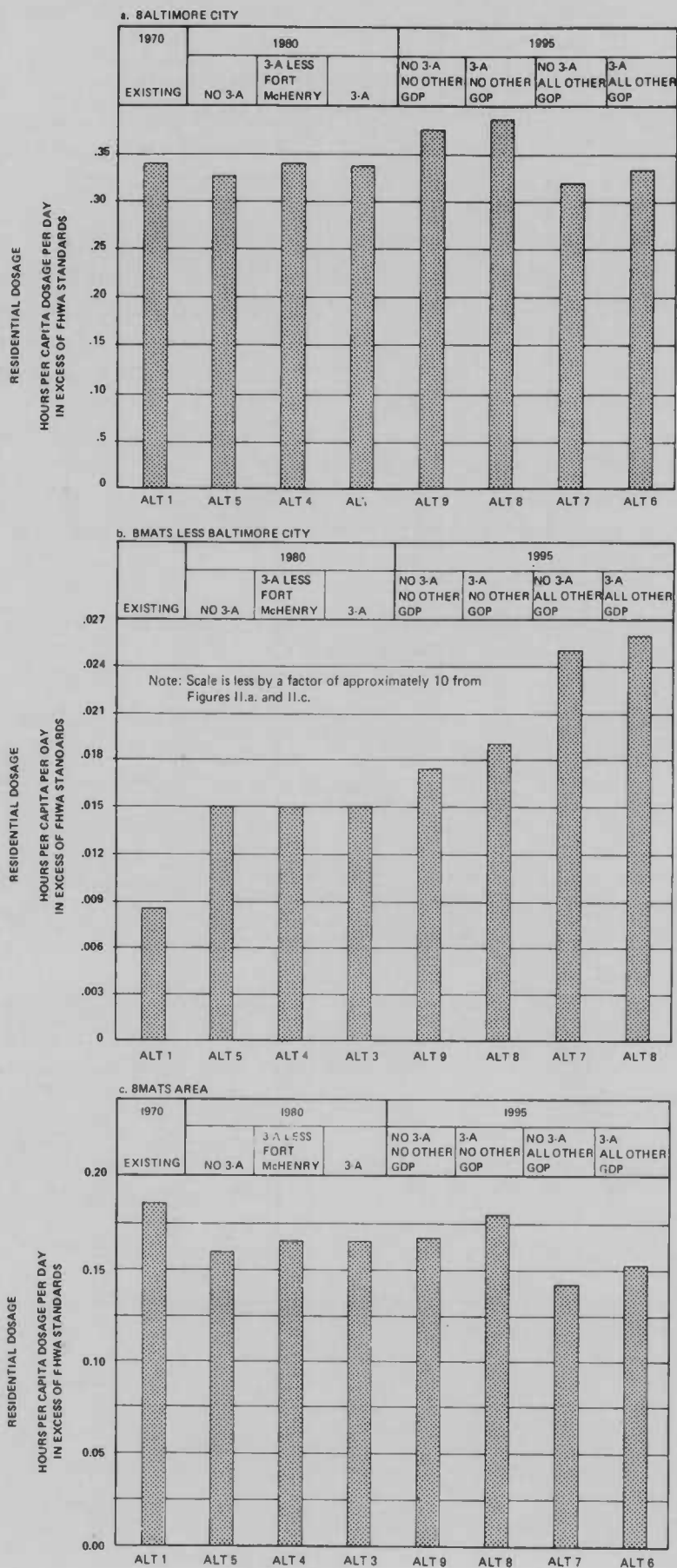
Throughout the study area, except for residential land usage, the greatest per capita noise dosage occurs during the day (7:00 a.m. to 6:00 p.m.). The high traffic levels and occupancy of non-residential land use areas during these hours produce this effect. In addition, the installation of noise abatement devices along much of the 3-A system significantly reduces the direct noise intrusion from the 3-A system.

Background sound levels were also calculated for the alternatives. The contribution to the background sound level from roadway vehicles depends on the ratio of vehicle miles traveled per acre and total number of street miles per acre. In Baltimore City, the primary background sound source is roadway vehicular activity, whereas in many of the outlying districts (particularly outside BMATS) the natural generators of sounds such as wildlife and wind produce the primary contribution to background sounds. The predominance of traffic noise in the background will also apply to all forecast years.

In general, the per capita residential dosage has been considered the most representative index of noise impact. This index is used to rank the alternatives and to evaluate their implications. In this study, it is noted that the relative change in this dosage is usually limited to several percent among the various alternatives. Using the per capita residential dosage, and keeping in mind the small relative differences, the following comparisons among the alternatives have been established.

1. All future alternatives result in a smaller noise impact (per capita noise dosage) for the entire BMATS area.
2. The construction of the 3-A System increases the noise impact (per capita noise dosage) in Baltimore City although the planned extensive noise abatement devices assist in minimizing the impact. Thus, as shown in Figure II-1a, the alternatives with the 3-A System produce the highest per capita dosage inside Baltimore City.

FIGURE II-1 PER CAPITA RESIDENTIAL NOISE DOSAGE-BMATS AREA BY ALTERNATIVE



3. The contribution of the GDP improvements increases the noise impact outside Baltimore City. Thus, as shown in Figure II-1b, the alternatives involving the contribution of the GDP improvement plan produce the greatest per capita noise dosage outside Baltimore City.
4. For the region considered as a whole (described in Figure II-1c) in the short term (1980), Alternative 5 (no 3-A) produces the least per capita noise dosage by approximately 4 percent with only minor differences in the relative ranking between Alternatives 3 (Complete 3-A) and 4 (3-A less Fort McHenry Crossing). In the long term (1995), Alternative 7 (no 3-A, all other GDP improvements) produces the least noise impact. The addition of the 3-A System (Alternative 8--3-A and other GDP improvements) ranks second, producing a 7 percent increase in per capita noise dosage.

Independent of the selection of a specific alternative, several action items could be undertaken to minimize the noise impact:

1. Traffic controls (e.g., speed control, synchronization of traffic lights, widening of streets, etc.) which would minimize the generation of vehicular noise can significantly reduce sound levels.
2. The assignment of bus and truck routes to selected roadways will significantly reduce noise levels along corridors where trucks and buses can be eliminated.
3. Land use controls (e.g., location of roadside development, development designs, construction material, etc.) can significantly reduce actual noise exposure of people in the vicinity of the road facility.
4. The installation of noise abatement devices over sensitive segments of the GDP Improvement Plan can significantly reduce noise levels in the vicinity of the roadway. Such devices could be similar to those planned for the 3-A system.

III. INTRODUCTION

This technical memorandum describes the assumptions, analyses and results regarding the noise impact under the BREIS alternative transportation and land use plans. This introduction first defines noise and then discusses the methodology employed to predict noise levels and the community noise impact for each alternative.

DEFINITION OF NOISE

A noise is usually defined as a sound which is unwanted, annoying, or disturbing. Since individuals often respond differently to the same sound, the perception of annoyance varies among individuals. An extreme example of this fact is demonstrated in the unusual case where a man built his home as close as allowable to the Seattle-Tacoma International Airport because he enjoyed hearing the roar of jet aircraft sounds. Clearly, most people would have found these levels extremely annoying and would describe the intense jet aircraft sounds as noise.

Community sound levels are usually measured and described by the dBA scale, which is a logarithmic, rather than linear, measure of sound intensity. In addition, the scale is weighted to adjust for the average human auditory response to sounds. Table III-1 lists representative examples of common sounds and their dBA levels. As can be seen from this figure, most common sound levels are between 40 and 80 dBA. For example, a normal conversation has a sound level of 60 dBA; a garbage disposal produces a sound level of 80 dBA; and a jet aircraft flyover at 1000 feet produces a sound level of 100 dBA. The dBA scale has been used in this study to define sound levels.

Because of the logarithmic nature of the dBA scale, when the actual sound energy intensity or the number of sound sources is increased by a factor of two, an increase of 3 dBA in sound levels results. Thus, if at some distance from a particular sound source a 70-dBA level is heard, then the addition of another similar independent source will cause the sound level to increase to 73 dBA. A 10-dBA increase in sound levels denotes a factor of 10 greater intensity; a 20-dBA increase in sound levels denotes a factor of 100 greater intensity. However, the psychological response of a majority of people to a 10-dBA increase in sound is to sense "a doubling" of the sound level. A 1- or 2-dBA change in sound level is not discernible by most people.

Although individual response to sound varies, general indices of noise can be established for the human population as a whole. There are two different categories of effects of noise upon people -- psychological and

TABLE III-1
ILLUSTRATIVE SOUND LEVELS MEASURED IN dBA

<u>Physiological Reaction</u>	<u>Level</u>	<u>Common Representative Sounds</u>
Threshold of Pain	120	
	110	
	100	Jet flyover at 1000 feet
Auditory Damage ⁺	90	Jackhammer heard at 25 feet
Onset of Auditory Damage*	80	Garbage disposal heard at 3 feet
	70	Vacuum cleaner heard at 3 feet Busy restaurant
	60	Normal speech heard at 10 feet Window air conditioner at 10 feet
	50	Quiet office
	40	Residential areas at night
	30	
	20	Studio for sound pictures
	10	
Threshold of Hearing	0	

+ Auditory damage level as defined by the Walsh-Healy Act is an 8-hour exposure to 90 dBA.

*According to the EPA "Legal Compilation," 8-hour exposure to 80 dBA levels are potentially hazardous to some individuals.

physiological. The psychological effects are dependent upon the individual and the characteristics of the sound other than its intensity. People who work in a high occupational noise climate may be less sensitive to community noise intrusion. Also, continuous noise has been found to be less annoying than intermittent noise. Certain sounds interfere with speech communication, and these sounds are often considered annoying. The activity in which the person is involved also determines his or her sensitivity to noise. Typically, people are not as sensitive to noise when working or shopping as when residing at home or studying at school.

The physiological effects include sleep intrusion, vasoconstriction (constriction of veins), and loss of hearing. Sleep intrusion occurs when noise causes a person either to waken or when it changes the depth of sleep. The levels that cause sleep intrusion and actual harm have not been determined. Vasoconstriction occurs for sound levels over 70 dBA and the degree of constriction is proportional to the number of decibels by which the level exceeds 70. Vasoconstriction is presently considered only potentially dangerous.

Hearing loss depends on sound intensity level and derivation. It is believed that exposure to a sound level of greater than 80 dBA for 8 hours a day can cause hearing loss.

NOISE LEVELS

Community annoyance from traffic sounds is related to both the intensity and fluctuation in intensity of such sounds. Close correlation between annoyance and the sound pressure level exceeded ten percent of the time (L_{10}) has been established in previous studies. This criterion has been selected by the Federal Highway Administration to index the standards. In order to explain the meaning of L_{10} , consider a 10-minute segment of traffic sound which varies in intensity as clusters of automobiles, or a single large truck, pass by the observation point. For a total of one minute out of the 10-minute segment, (i.e., 10 percent of the time) the sound pressure level exceeds some specific intensity value; this value is called the L_{10} .

COMMUNITY NOISE ANALYSIS

The primary objective of this study is to develop a set of quantitative criteria for evaluating the community impact of noise in the study area and to employ these criteria to determine relative effects of the various transportation and land use alternatives.

The first phase of the study was to adequately understand the present sounds in the area. Previous studies have been performed regarding the noise impact of the 3-A system in various neighborhoods and at certain receptor locations. (1) However, the scope of these previous studies did not evaluate the noise impact to the entire community. For example, although it is possible to protect the area immediately proximate to the highway from significant noise intrusion by installing the proper noise abatement devices, the freeway link may substantially alter traffic flows on other streets. The potential change in noise impact from this traffic modification must be explicitly addressed in order to assess the net noise impact on the community. Previous studies often failed to account for this. Although installation of adequate highway abatement devices may be sufficient to reduce noise levels originating from the freeway, in some locations, community noise may increase due to induced traffic on adjacent roads.

The present study involved field measurements to determine the sound levels and sources of sound at locations in the study area removed from the immediate vicinity of either the 3-A system expressways or other major roads. In addition, the field measurements were used to calibrate and substantiate the sound propagation program.

The criteria selected for evaluating noise impact are:

- Community dosage of excessive noise levels expressed as the number of people hours the afflicted population is exposed.
- Community dosage of excessive noise levels expressed as the number of people hours per capita, by category of receptor population.

Excessive noise levels, illustrated in Table III-2, are defined in the recent Federal Highway Administration (FHWA) Policy and Procedure Memorandum (PPM 90-2). This document is reproduced in Appendix A, and Table III-2 summarizes the noise guidelines.

Criteria such as these differentiate between sounds produced by highway traffic in vacant areas and those produced in occupied areas. Land use information and roadway traffic are accounted for in this procedure. The calculation of community noise impact is a complex procedure performed by a computer program. This study employed the ESL sound propagation model, which is described in Appendix B. The model is consistent with the Highway Research Board Report 117, which is the standard prediction methodology designated by the Federal Highway Administration.

TABLE III-2
DESIGN NOISE LEVEL/LAND USE RELATIONSHIPS*

<u>Land Use Category</u>	<u>Design Noise Level--L₁₀</u>	<u>Description of Land Use Category</u>
A	60 dBA (Exterior)	Tracts of lands in which serenity and quiet are of extraordinary significance and serve an important public need, and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose. Such areas could include amphitheaters, particular parks or portions of parks, or open spaces which are dedicated or recognized by appropriate local officials for activities requiring special qualities of serenity and quiet.
B	70 dBA (Exterior)	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals, picnic areas, recreation areas, playgrounds, active sports areas, and parks.
C	75 dBA (Exterior)	Developed lands, properties or activities, not included in Categories A and B above.
E	55 dBA (Interior)	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals, and auditoriums.

*From Federal Highway Administration PPM-90-2, dated February 8, 1973.

The traffic and land use data in the noise analysis are the basic inputs for the community dosage calculation. The derivation of these data are described in Technical Memorandum No. 1, "Socioeconomic and Land Use Analysis", and Technical Memorandum No. 2, "Traffic and Travel Analysis". The traffic data is confined to the BMATS study area shown in Figure I-5.

The projected 24-hour average daily traffic (ADT) volumes over the entire roadway network, the projected land use classes by Regional Planning District (RPD), and the estimated percent of ADT per hour are input requirements for the program. This program can, therefore, assess the interactions among the various decision parameters (i.e., input requirements) in determining the community noise dosage.

In areas of the Baltimore region where detailed land use and traffic data are not available, the noise dosage could not be calculated. For these cases, the criterion was the sound level near a typical roadway.

The first criterion, community dosage of noise, is measured in terms of the number of person hours exposed to a noise level in excess of some standard level. For example, if in a community of 1,000 people, one fourth of the population (250 persons) is exposed to noise levels in excess of a standard for 2 hours each day, the 24-hour total dosage would then be 500 (250 persons x 2 hours) person-hours. The second criterion, the community dosage per capita is 500 person-hours divided by the total population of 1,000 persons, or 0.5 hours per capita.

Four classes of activities are used in this analysis to measure noise impact. These input categories were derived from the BREIS land use analysis, Technical Memorandum No. 1.

- Residential--People residing at home.
- Institutional--Government employees and students at their respective institution (hospitals, schools, libraries, etc.)
- Commercial--Retail employees working at commercial business (retail employment is representative of overall commercial growth in the forecast years).
- Industrial--Employees at industrial jobs.

The FHWA PPM 90-2 standards, summarized in Table III-2, were applied to the above classifications in this study. Residential and institutional classes both came under FHWA land use categories B and E. The exterior

standard (FHWA Category B) is an L_{10} of 70 dBA and the interior standard (FHWA Category E) is an L_{10} of 55 dBA. Modern building structures reduce interior levels 10-20 dBA, depending on whether windows are open or closed and on the geometrics of sources and building walls. Therefore, in general, compliance with the exterior level (70 dBA) under typical circumstances will cause compliance with interior level (55 dBA). For the purposes of this study, only the exterior level is explicitly examined. The commercial and industrial classes fall into the FHWA land use category C. This category specified a 75-dBA exterior level.

GENERAL ASSUMPTIONS

In performing the noise impact analyses in this study, the following general assumptions regarding the socioeconomic conditions, traffic projections, noise control regulations, and the effectiveness of planned noise abatement devices were made:

- The traffic projections and land use growth which were described in Technical Memorandum No. 1 ("Socioeconomic and Land Use Analysis") and No. 2 ("Traffic and Travel Analysis") were employed; therefore, the underlying assumptions and methods involved in these studies became assumptions of the noise study.
- The developmental process which resulted in the present land use adjacent to the roadways in the study area will continue unaltered through 1995.
- Although there is active consideration on the part of many government agencies to regulate vehicular noise emissions, the effectiveness of such programs has not been established. Therefore, for this study, it was assumed that the emission of noise from vehicles, in particular trucks, would not change in future years. Even if future regulations result in the reduction of vehicular noise emissions, the relative community dosage among the alternatives will remain the same.
- The noise abatement devices which are presently intended for installation, particularly along the 3-A system, will be effective in achieving their design goals.

ORGANIZATION OF THE REPORT

Chapter IV examines the present noise climate in the study area, including the results and implications of the field work program performed in this

effort. In addition, there is a validation section comparing the measured values near a freeway to the results of the sound propagation model. Chapter V presents the basic noise analyses. The community dosage in the BMATS area is discussed, the typical noise levels in the area outside BMATS are presented, the background noise levels are presented, and the impact of transit stations and other sources are analyzed. Finally, Chapter VI summarizes the results and presents the conclusions.

IV. EXISTING SOUND LEVELS

In order to assess noise effects in future years it was necessary to characterize existing sound levels throughout the region, to define the sources of excessive sounds, and to develop a base from these data on which to validate the sound propagation model.

SOUND MEASUREMENT PROGRAM

An extensive field measurement program was employed throughout the study area. Measurement equipment included Bruel and Kjaer Sound Level Meter which conforms to the Type 2 American National Standards Institute (A.N.S.I.) specifications and appropriate International Electrotechnical Commission (I.E.C.) standards. The microphone was placed on a free-standing tripod and equipped with a spherical wind screen. Signals from the microphone were amplified by the sound level meter; in addition, the meter's A weighting network was employed. In this fashion the meter indicated the dBA sound levels at the microphone. For most of the measurements, the dBA signal was recorded on a strip chart recorder; samples of such recordings are given in the following sections. During all measurements, the nature and sources of the sound was recorded by the field technician.

URBAN SOUND LEVELS

Roadway Sounds

Field measurements of roadway sounds were made for a variety of roadway design types and under different traffic conditions. Table IV-1 describes these measurements in detail and compares the measured values to values predicted by the sound propagation model. As can be seen from this table, almost all of the predictions are within one standard deviation of the measurement mean. Thus, the experimental field data validate the prediction technique. Sound levels near these roadways are often in excess of the L_{10} dBA standard of 70 dBA and occasionally exceed the 75-dBA standards. As can be seen in the table, these levels can be exceeded by either major highways or heavily trafficked city streets.

Reproductions of two typical graphs of sound levels are shown in Figure IV-1. The peak values in these graphs are caused by the passing of a heavy truck or a closely packed group of automobiles. Those peaks with sharp rise and fall times are related to single trucks and those with more gradual slopes to automobile clusters.

TABLE IV-1

MEASURED vs. PREDICTED L₁₀ dBA SOUND LEVELS IN STUDY AREA

(May 1973)

Time of Day	Measurement*	Model Prediction**	Location and Description Comments
10:45 a. m.	66	67	Near Baltimore and Calvert light wind, overcast, in parking lot surrounded by high buildings.
12:10 p. m.	76	77	Near Patterson and Eastern, light wind, overcast, moderate traffic.
12:45 p. m.	80	78	On Boston Street near intersection of Hudson and Montford, moderate traffic, airplace, overcast, light wind
1:10 p. m.	73	78	On Boston between Clinton and Highland, near railroad, overcast, mild wind.
1:30 p. m.	77	77	Corner of Boston and Newkirk near industrial plant, overcast, moderate traffic, light wind, near railroad.
2:15 p. m.	70	74	On President between Lancaster and Aliceanna, near dock, railroad, and construction, cobblestone street, overcast.
4:50 p. m.	64	63	Residential street between I-83 and Druid Lake, light wind.
5:15 p. m.	87	79	Between I-83 and railroad crossing train, jet, prop airplane.
9:10 a. m.	65	64	Near Caton Avenue and Benson Avenue, near Archbishop Keough High School, overcast, windy.
9:35 a. m.	65	70	Off Caton Avenue near Caton Manor Nursing Center, St. Agnes Hospital and Cardinal Gibbons High School, overcast, windy, birds, jet, moderate traffic
10:05 a. m.	62	58	Near Carroll Golf Course off Washington Blvd. next to creek, gusty winds, overcast, moderate traffic
11:45 a. m.	64	67	Near Baltimore and Calbert, overcast, light winds, surrounded by high buildings
2:25 p. m.	70	66	On Sandy Spring Road in residential area separated from I-95 by trees
2:40 p. m.	68	70	Corner of Calvert & E. Pleasant, light haze, near Mercy Hospital.

Table IV-1, Continued

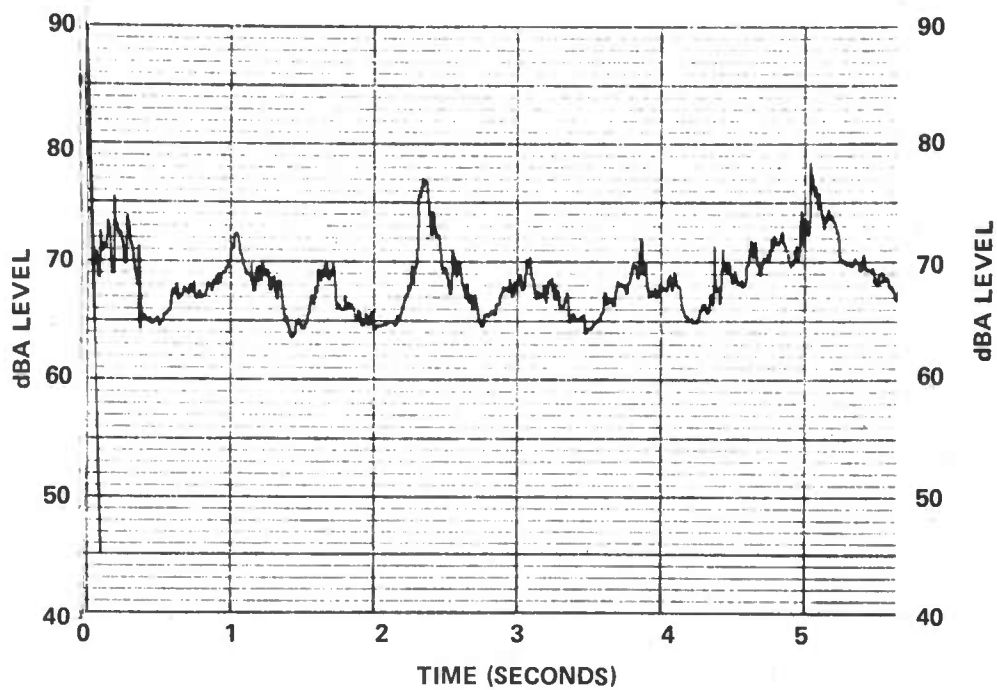
<u>Time of Day</u>	<u>Measurement*</u>	<u>Model Prediction**</u>	<u>Location and Description Comments</u>
3:30 p. m.	60	60	On E. Read between N. Charles and N. Love Grove, clear
4:05 p. m.	70	68	On W. Franklin near Jasper, overcast, heavy traffic
4:25 p. m.	74	72	On Arlington & W. Franklin near Francis M. Wood High, overcast, light wind, moderate traffic, children
2:50 p. m.	69	74	Corner Mount & Mulberry, moderate traffic, haze, light wind, dog barking
5:15 p. m.	74	70	On W. Franklin near Pulaski, haze, light wind, moderate traffic, voices, dog.
5:30 p. m.	75	76	W. Franklin near N. Franklinton, heavy traffic, radio noise in distance, haze, light wind.
5:35 p. m.	79	77	W. Franklin near N. Franklinton heavy traffic, radio noise in distance, haze
6:10 p. m.	68	71	On Redwood at Greene near University of Maryland Hospital, overcast.
11:50 p. m.	68	66	Near Calvert and Baltimore, light traffic
2:30 p. m.	77	78	Corner of Boston & Newkirk near industrial plant overcast, light wind, near railroad
3:55 p. m.	76	76	N. Central near E. Monument, near E. Monument, near Thomas G. Hayes Elementary School, windy, traffic stop and go, overcast.
8:00 a. m.	72	74	Near Baltimore & Calvert, overcast, light wind, surrounded by tall buildings.
8:15 a. m.	69	68	On Mount between W. Mulberry and Saratoga, heavy traffic
8:35 a. m.	78	76	Near Carroll Golf Course & Washington Blvd., near creek
8:45 a. m.	79	79	Off Caton Avenue near Caton Manor Nursing Center, St. Agnes Hospital and Cardinal Gibbons High School, overcast, windy, birds, jet, moderate traffic
12:30 p. m.	70	72	Corner Mount near Mulberry, moderate traffic, overcast, windy

Table IV-1, Continued

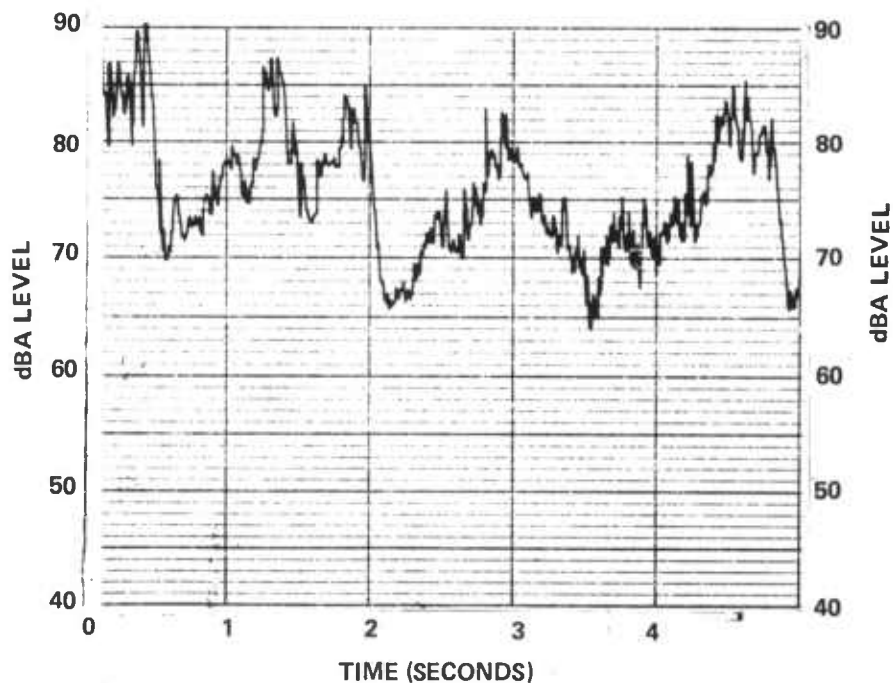
Time of Day	Measurement*	Model Prediction**	Location and Description Comments
12:45 p. m.	76	76	On Franklin, near Pulaski, windy, overcast, men working, voices
1:00 p. m.	80	79	W. Franklin near N. Franklinton, heavy traffic, windy
9:15 a. m.	70	72	On Mount near Franklin, moderate traffic, mild wind, voices, whistling
9:35 a. m.	74	73	On Franklin near Pulaski, dogs, radio in distance and mild wind
9:50 a. m.	74	75	Franklin and Franklinton, moderate traffic, mild wind.

*L₁₀ dBA -- All figures + 3 dBA margin of measurement error.

**L₁₀ dBA



SOUND LEVELS NEAR MOUNT AND MULBERRY
IN BALTIMORE CITY



SOUND LEVELS AT PATTERSON &
EASTERN IN BALTIMORE CITY

FIGURE IV-1. TYPICAL URBAN ROADWAY SOUND GRAPHS

Non-Roadway Sounds

In addition to the vehicle sound sources, other urban sources contribute to the sound levels in the study area. Measurements taken at locations removed from roadway indicate these other sources. Table IV-2 describes such measurements, and Figure IV-2 is a time graph of two sample measurements. As can be seen from these data, frequently non-roadway sources can significantly add to the urban sound levels.

However, except for locations near jet aircraft, the peak levels are below those observed near roadways.

RURAL SOUND LEVELS

Table IV-3 describes measurements made in rural areas far removed from roadways; Figure IV-3 shows the location of these measurements. As can be seen from the table, the noise levels are usually considerably lower than those near roadway or miscellaneous urban sources. The data from this table indicates that "natural" sources of sound produce a baseline L_{10} sound level of at least 40 dBA during the summer months.

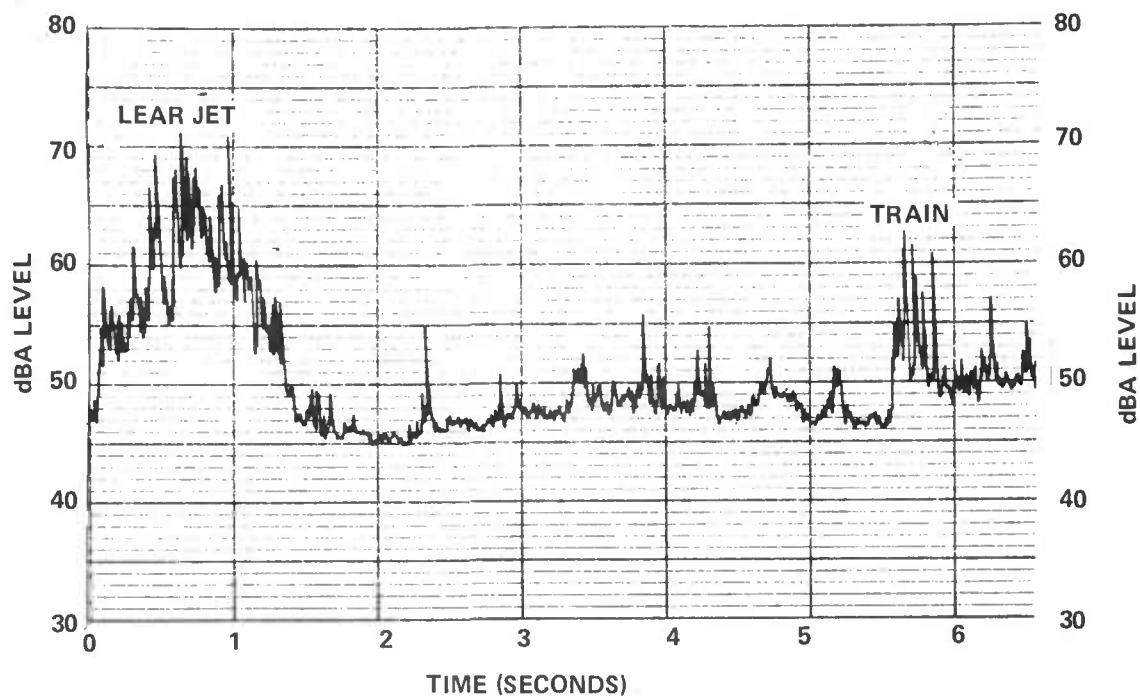
SUMMARY

From the field sound measurement program, it was found that, depending on the location, the intensity and characteristics of the sounds in the study area vary considerably. Sound sources proximate to the location under question tend to dominate the sound levels. Locations in rural areas removed from highways and other man-made sound sources were characterized by sounds generated by the wind interacting with trees, fallen leaves and brush; in addition, at some locations, small animals and insect noise contributed significantly to the sound levels. In some rural areas the locust sounds were measured to reach peak levels of 70 dBA. Daytime L_{10} levels in these areas ranged from 50-55 dBA. The sound levels in residential and commercial areas in both rural and urban regions were usually predominated by nearby auto and truck traffic. L_{10} levels in these areas ranged from 45-80 dBA. This wide range in levels is due to the widely different local traffic volumes and speeds. The sound levels at various institutions were similar to those in residential and commercial centers.

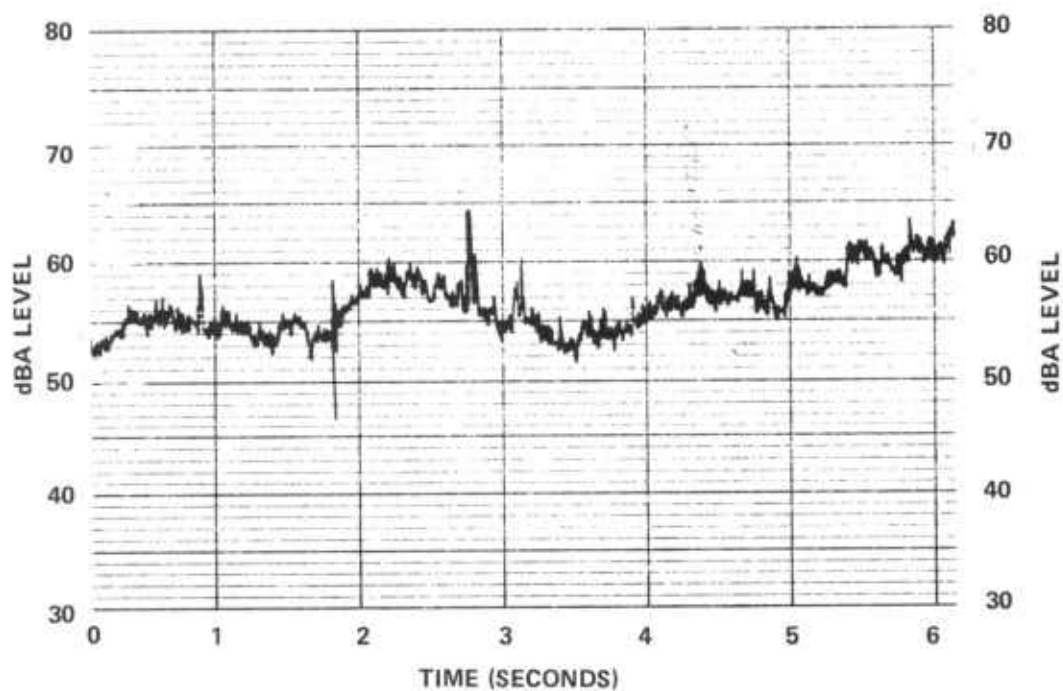
The sound levels near special sound sources such as airports, industries, and train tracks were often dominated or at least significantly influenced by these sources. A typical freight train in the study area generates sufficient sound energy that levels of 70 dBA were measured at distances up to 250

TABLE IV-2
SOUND LEVELS AT MISCELLANEOUS URBAN SITES
(May 1973)

Time of Day	Measurement			Location Description & Comments
	L10	L50	L90	
4:10 pm	54	48	47	Urban area thickly wooded and littered; light wind, near Druid Lake, sounds from birds and propellor planes
12:20 pm	62	49	46	Between Pennsylvania Central and B&O railways, sounds from trains
10:00 am	61	54	48	End of McComas St. near Race St. in Swan Park, sounds from planes, trains, and a slow car
10:50 am	52	48	44	Near Ft. McHenry and Northwest Harbor, sounds from birds, people, and planes



SOUND LEVELS BETWEEN B & O AND PENN
CENTRAL RAILWAYS IN BALTIMORE CITY



SOUND LEVELS IN SWANN PARK
IN BALTIMORE CITY

FIGURE IV-2. SAMPLE OF URBAN SOUND MEASUREMENTS AWAY FROM
THE ROADWAY

TABLE IV-3
SOUND LEVELS AT RURAL SITES REMOVED FROM ROADWAY
(August 1973)

Location	Time of Day	Measurement			Comments
		L10	L50	L90	
Howard County Off I95 & Md. 175E	6:10 am	57.9	56.0	55.5	Wooded area, distant train whistle, calm, birds
Anne Arundel County Off Md. 175E	6:45 am	55.0	53.5	52.2	Small animals, distant airplane, distant train, calm
Perkins Clifton State Hospital	7:15 am	55.0	51.7	50.5	Distant lawnmower, voices, helicopter, distant train, calm, people walking, locust
Baltimore County Arlington St. near Rolling Rd.	7:55 am	57.3	54.0	52.8	Distant small plane, dogs, locust, distant train station, birds
Trinity School Landing Road	8:30 am	61.0	56.0	49.0	Woods surrounding open field & school buildings, locust, birds, distant jet and small airplane
The Oaks Road off Md. 40 in Baltimore County	9:05 am	59.0	56.0	54.2	Flat fields, distant airplane, slight wind
Off Pleasant Valley Road Off Rolling	10:00 am	62.4	56.0	48.1	Locust in woods back of line of houses, distant construction
Social Security Building Parking lot	1:15 pm	63.0	59.0	56.6	Distant traffic, few cars in search of parking stall
Hanlon Park Baltimore City	1:56 pm	65.1	56.5	50.0	Children playing, jet path overhead, open field
Rockdale Terrace Off Md. Rte. 26	2:30 pm	55.1	51.4	49.0	Near elementary school, apartment complex locust, small airplane overhead, I695 visible through trees
Chittenden Road	3:10 pm	54.5	52.0	48.5	Heavily wooded near golf course, birds, locust, helicopter
Bastad Court	3:50 pm	58.5	52.0	48.0	Near Trinity College in hills, wooded, birds, locust, planes in distance
Beaver Road Park	4:25 pm	53.2	52.5	52.0	Near brook, wooded on one side, locust, flat field on other side
Deer Pass Court	5:00 pm	57.0	50.1	45.0	Up in hills, neighborhood with children playing, dog, distant lawnmower, cars returning home
Daleview Road	5:35 pm	56.1	49.8	46.5	Hills, large residences, overhead airplane, moderately landscaped, secluded

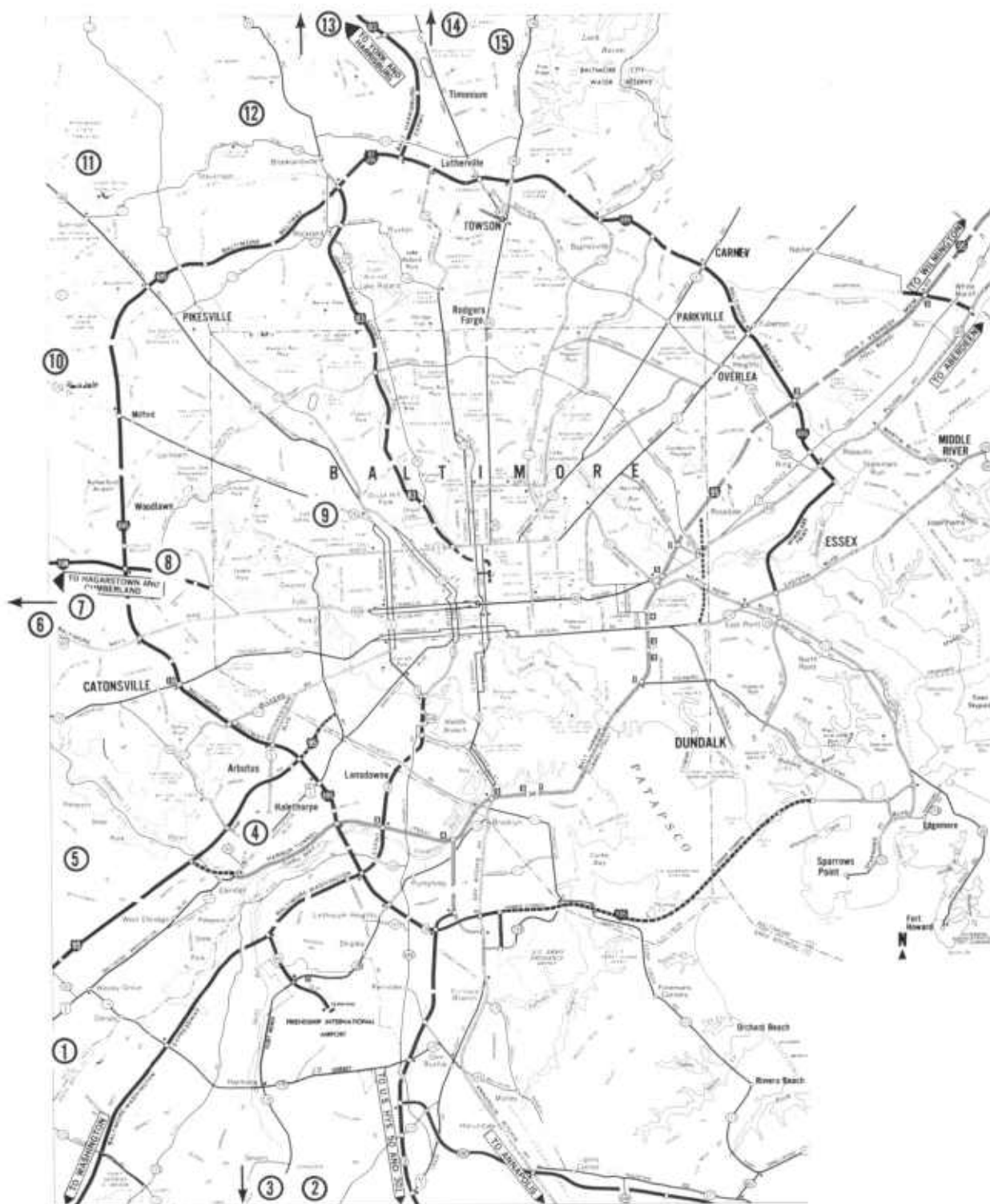


FIGURE IV-3. MAP OF RURAL SOUND MEASUREMENT SITES

feet from the tracks while the trains passed. Because the trains passed infrequently over most of the system, their contribution to the L_{10} sound level was often small; however, they were the source of maximum community sound levels in the area. Aircraft activities related to the major airports also contribute significantly to sound levels in regions below the flight paths. Many outdoor industrial activities contribute significantly to the sound levels in their proximity in the study areas. The sound levels in both rural and urban residential areas that are removed from major arterials and other sound sources are usually predominated by local traffic. The construction and design of individual residential developments, particularly apartment buildings and other multiple dwelling units, determines the extent to which sounds generated by people's activities at home intrudes on neighbors.

V. NOISE DOSAGE METHODOLOGY

This section describes in detail the methodology used to calculate both the community noise dosage and the per capita noise dosage inside the BMATS area. Section VI evaluates the relative merits of the alternatives based on the results obtained using this methodology. However, a reading of this section is only informative to those interested in the technical details of the methodology.

COMMUNITY DOSAGE INSIDE THE BMATS AREA

The community dosage measured in total person-hours and per capita dosages from the roadway network were calculated for the following geographical areas:

- Total area inside BMATS
- Baltimore City
- Baltimore County inside BMATS
- Anne Arundel County inside BMATS
- Howard County inside BMATS

In each of the above categories, noise dosages were analyzed for the four land use classes: residential, institutional, commercial and industrial.

The first step to calculate the community dosage of noise was to determine the present land use adjacent to each of the network roads. Each regional planning district (RPD) in the BMATS area was studied to determine these land uses. Figure V-1 is a schematic representation of an RPD land use and network map. The fraction of the total highway and major arterial miles adjacent to the different land use categories was measured from maps such as Figure V-1. Table V-1 is a hypothetical analysis of Figure V-1. The land use near network links which are neither freeways nor major arterials may differ from these categories; however, no accurate information was available to describe such a difference. Therefore, the simple assumption was made that the same percentages applied to all the roadways in the network system.

The next step was to determine the density of each of the four land use categories for the 1970 Alternative (Existing); residential, commercial, institutional and industrial acreage were supplied from the BREIS socioeconomic analysis.

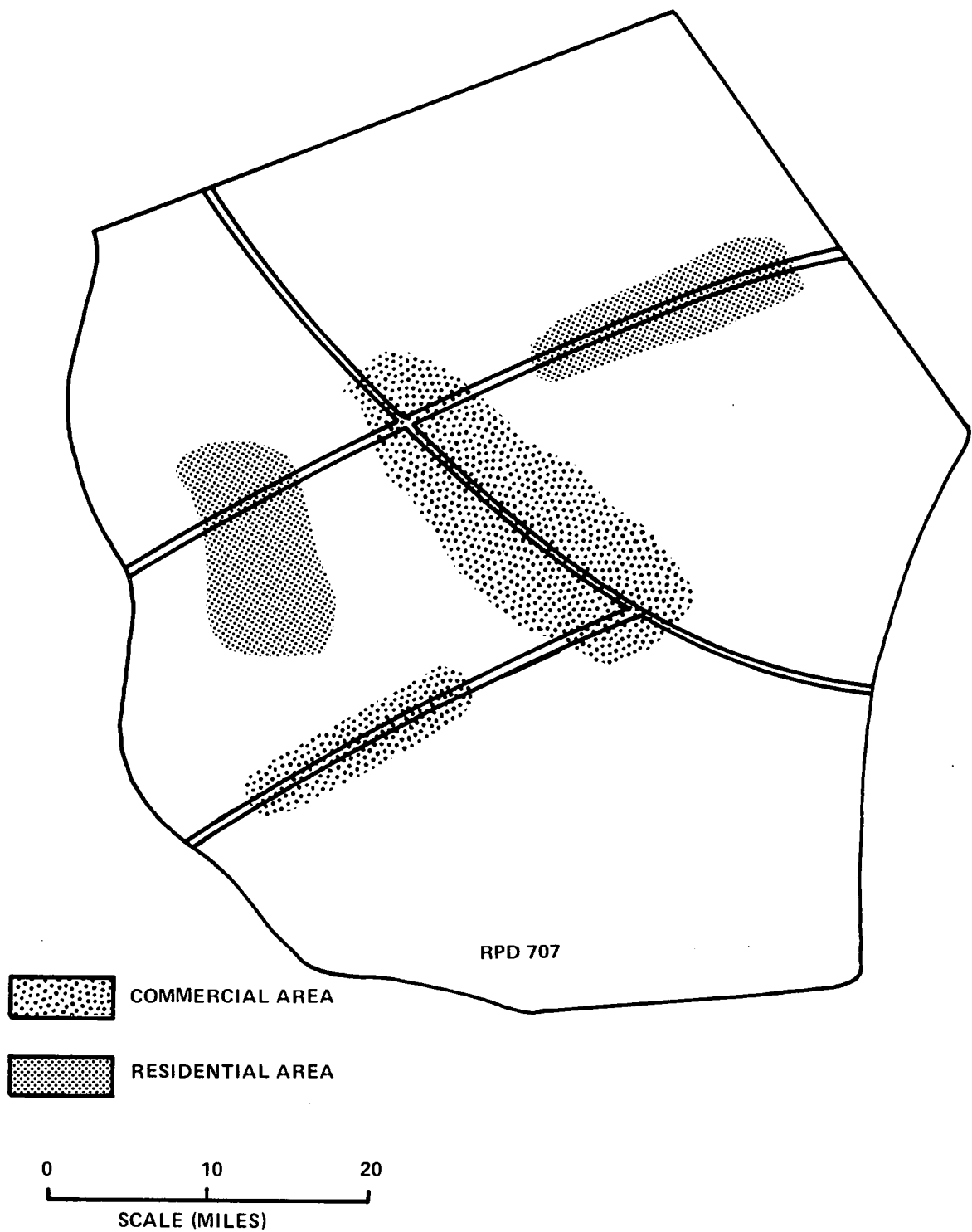


FIGURE V-1. ILLUSTRATION OF RELATIONSHIP BETWEEN LAND USE AND ROADWAY LOCATION

TABLE V-1
LAND USE-ROADWAY ANALYSIS OF RPD 707 (Figure 5-1)

Total Length of Roads in RPD	132
Length of Roads Adjacent to Residential Areas	24
Length of Roads Adjacent to Commercial Areas	55
Fraction of Road Adjacent to Residential Areas	$\frac{24}{132} = 18.2\%$
Fraction of Road Adjacent to Commercial Areas	$\frac{55}{132} = 41.7\%$
Fraction of Road Adjacent to Unoccupied Areas	$\frac{53}{132} = 40.1\%$

The densities were calculated as the ratios of: population to gross residential acreage; government employment and attendant students to institutional acreage; retail employment to commercial acreage; and intensive employment to industrial acreage. Except for Alternative 1 (1970, Existing) commercial, institutional and industrial acreages were not available. Thus, the densities for those alternatives were calculated differently as the product of the 1970 density and the ratio of the current employment to the 1970 employment.

To account for the location of the general population at different times of the day, a set of probability factors was developed to locate the people with respect to the four classes (residential, commercial, institutional and industrial) during each hour of the day. For example, a typical retail employee is not on the job at 2 a.m.; thus the 2 a.m. noise dosage he experiences cannot contribute to the commercial noise dosage. Appendix C contains additional diurnal variation information.

The individual dosage from each link was then calculated using the appropriate land use information, respective densities and the individual link length, probability factor, and input from the noise prediction model.

The following basic assumptions are implicit in the formulation of the community dosage inside BMATS:

1. In each RPD, the relationship between land use adjacent to roadways and the demographic composition of the RPD will remain constant in future years (i.e., a 10 percent increase in residential population will be accompanied by a 10 percent increase in residential land use adjacent to roadways).
2. The acoustic sound abatement devices in the present construction plans will be effective in achieving their design goals.
3. The land use adjacent to the highways and major arterials is similar to the land use adjacent to the entire network road system.
4. There is no significant reduction in acoustic energy generated by roadway vehicles in future years.

Calculation Employed

A computer program was developed which utilizes the ESL sound propagation model as shown in the flow chart, Figure V-2. Different types of input

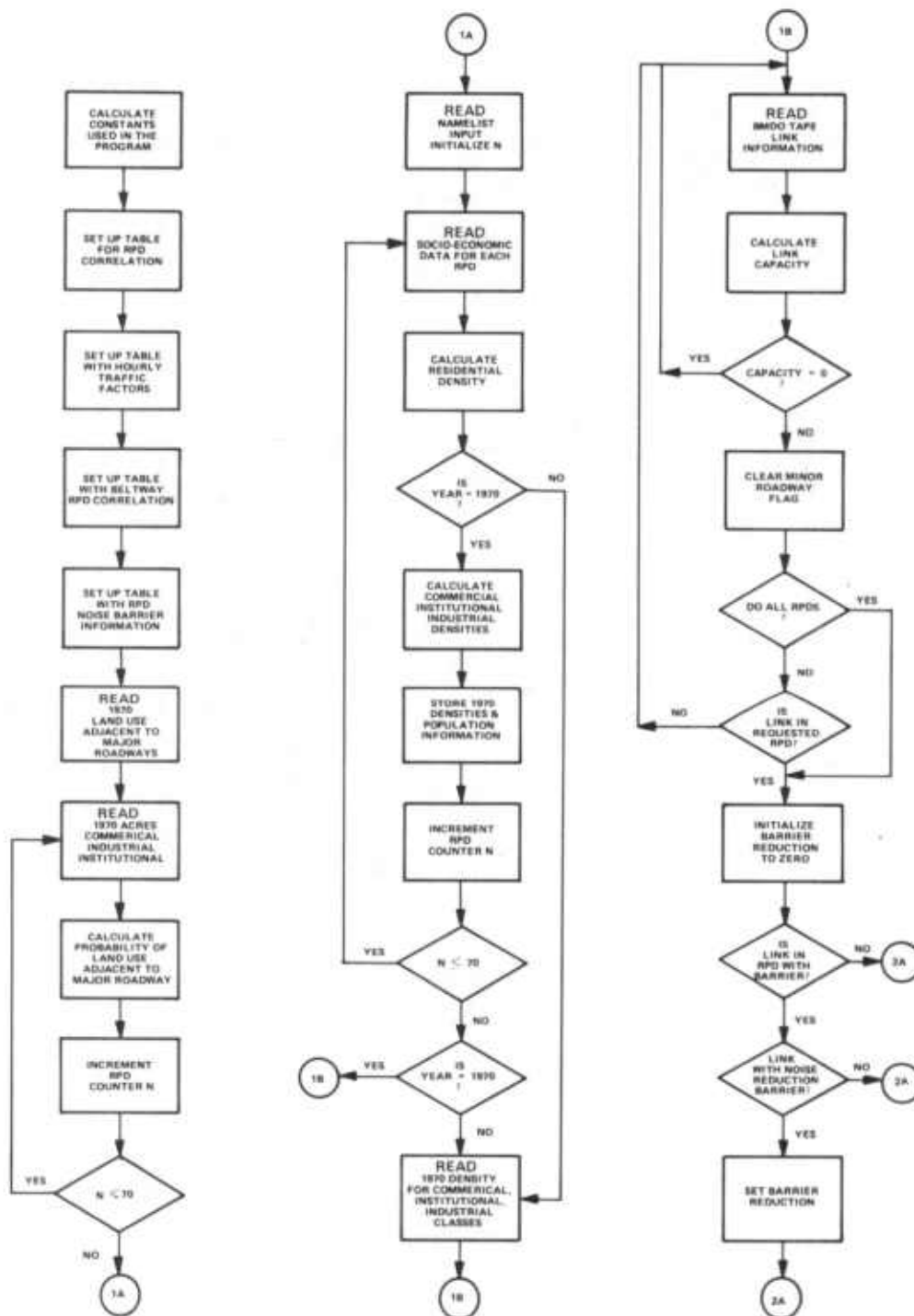


FIGURE V-2. FLOWCHART OF BALTIMORE NOISE PREDICTION COMPUTER PROGRAM (1 OF 3)

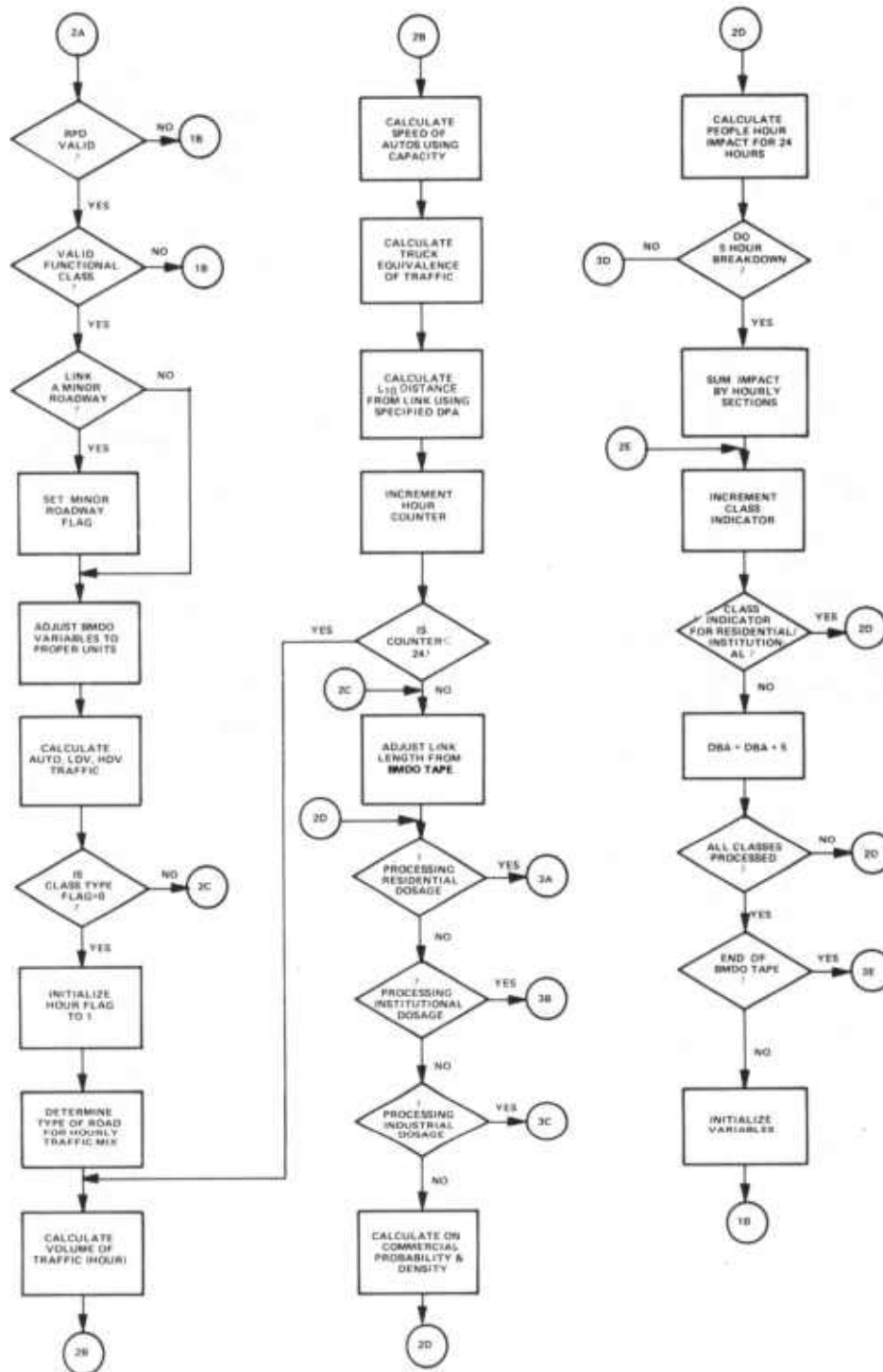


FIGURE V-2. FLOWCHART OF BALTIMORE NOISE PREDICTION COMPUTER PROGRAM (2 OF 3) CONTINUED

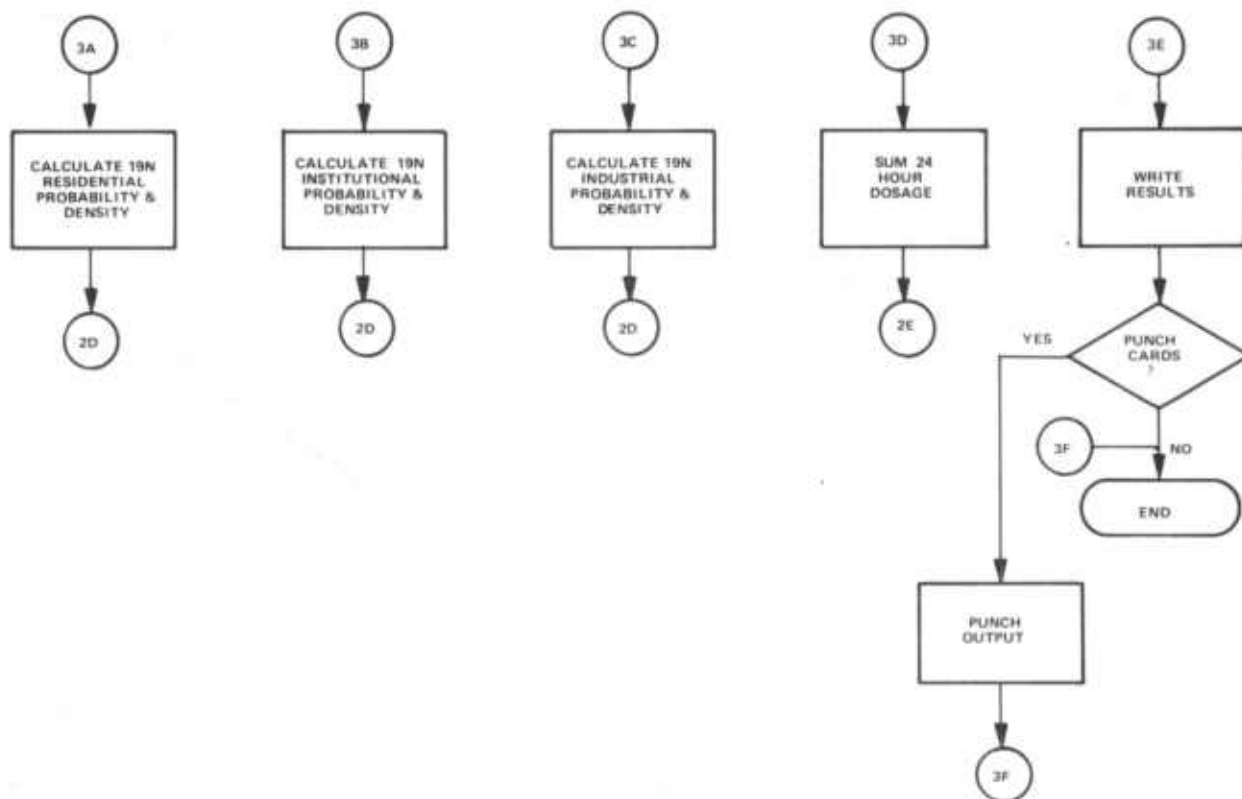


FIGURE V-2. FLOWCHART OF BALTIMORE NOISE PREDICTION COMPUTER PROGRAM (3 OF 3) CONTINUED

were required. A description of the inputs for the noise analysis computer program is contained in Appendix D. A list of RPDs inside BMATS as shown in Table V-2 was used to select travel data from the travel simulation process (Technical Memorandum No. 2). The analysis was summarized by jurisdiction as shown in Table V-3. To calculate noise dosages, the program utilized:

- Socioeconomic data on the RPD level
- General RPD land use for 1970
- Average daily traffic (ADT) information on the link level and vehicle miles of traveled (VMT) information on the RPD level
- Diurnal distribution of traffic
- Traffic mix and information on land use adjacent to major arterials and highways in each RPD.

The computer program first screens out extraneous information, such as information about RPDs outside of the BMATS area. It then incorporates land use information adjacent to the highways and major arterials to calculate a probability of residences, institutions, industries, and commercial businesses existing near the major roadways. This was done for each of the 70 RPDs inside BMATS.

Parameters used to determine the type of noise dosage to be computed are:

- A choice of one RPD, all RPDs, or end program
- The L_{10} dBA level at which the calculations are to be made
- Year of the alternative to be calculated
- A choice between a 24-hour total dosage analysis or a breakdown into the following segments of the day:

11 p.m. - 7 a.m.
7 a.m. - 9 a.m.
9 a.m. - 4 p.m.
4 p.m. - 6 p.m.
6 p.m. - 11 p.m.

TABLE V-2
LIST OF VALID* RPDs

Inside BMATS:

101-126

201-210

303-331

603-607

Outside BMATS:

211-217

301-302

401-406

501-507

601-602

Inside Beltway:

101-126, 201, 314, 315, 316, 319, 320, 325, 326,
329, 330

*Valid indicates an RPD which is used in this analysis.
Some RPDs were present which were not relevant.

Once the type of noise dosage is determined, the program proceeds to calculate densities. The Alternative 1 was used as a baseline for future density calculations. The densities for the four classes of noise dosage are calculated for each RPD using the following equations:

$$D_R(1) = P/A_R \quad (1)$$

where:

$$\begin{aligned} D_R(1) &= \text{residential density Alternative 1} \\ P &= \text{population in RPD} \\ A_R &= \text{gross residential area (square feet)} \end{aligned}$$

$$D_{IS}(1) = (E_G(1) + S_A(1))/A_P \quad (2)$$

where:

$$\begin{aligned} D_{IS}(1) &= \text{institutional density for Alternative 1} \\ E_G(1) &= \text{government employment population in RPD for Alternative 1} \\ S_A(1) &= \text{attendent student population for Alternative 1} \\ A_P &= \text{gross public facility area (square feet)} \end{aligned}$$

$$D_C(1) = E_R(1)/A_C \quad (3)$$

where:

$$\begin{aligned} D_C &= \text{commercial density for Alternative 1} \\ E_R(1) &= \text{retail employment population in RPD for Alternative 1} \\ A_C &= \text{gross commercial area (square feet)} \end{aligned}$$

$$D_{ID}(1) = E_I(1) / A_I \quad (4)$$

where:

$$\begin{aligned} D_{ID}(1) &= \text{industrial density for Alternative 1} \\ E_I(1) &= \text{intensive employment population in RPD for Alternative 1} \\ A_I &= \text{gross industrial area (square feet)} \end{aligned}$$

For each of the future alternatives, the residential density is calculated with equation 1 above using applicable residential population and gross residential area. For these alternatives, the institutional, commercial, and industrial densities are calculated using the following equations:

$$D_C(N) = D_C(1) \times [E_R(N) / E_R(1)] \quad (1)$$

where:

$$\begin{aligned} D_C(N) &= \text{commercial density for Alternative N} \\ D_C(1) &= \text{commercial density for Alternative 1} \\ E_R(N) &= \text{retail employment population in RPD for Alternative N} \\ E_R(1) &= \text{retail employment population in RPD for Alternative 1} \end{aligned}$$

$$D_{IS}(N) = D_{IS}(1) \times [E_G(N) + S_A(N)] / [E_G(1) + S_A(1)] \quad (2)$$

where:

$$\begin{aligned} D_{IS}(N) &= \text{institutional density for Alternative N} \\ D_{IS}(1) &= \text{institutional density for Alternative 1} \\ E_G(N) &= \text{government employment population in RPD for Alternative N} \\ S_A(N) &= \text{attendant student population in RPD for Alternative N} \end{aligned}$$

$E_G(1)$ = government employment population in RPD
for Alternative 1

$S_A(1)$ = attendant student population in RPD for
Alternative 1

$$D_{ID}(N) = D_{ID}(1) \times [E_{ID}(N) / E_{ID}(1)] \quad (3)$$

where:

$D_{ID}(N)$ = industrial density for Alternative N

$D_{ID}(1)$ = industrial density for Alternative 1

$E_{ID}(N)$ = intensive employment population in
RPD for Alternative N

$E_{ID}(1)$ = intensive employment population in
RPD for Alternative 1

The program next reads the traffic tape which contains information for every link in each alternative. The computer program has the capability either to do a specific RPD by reading through the tape and processing only the proper one or to process all RPDs inside BMATS.

When calculation begins on each individual link, the program first determines if any pertinent information on roadway construction is available, i.e., noise barriers, or if the link is in a tunnel, etc. Sound level reductions due to acoustic sound level barriers are taken into consideration at this point in the computer program. All centroid connectors, minor arterials, and collectors are distinguished for later calculation.

The roadway capacity, capacity speed, and average daily traffic are listed for each link. A table stating the percent of ADT by hours of the day and vehicular mix is used with the link information to calculate the traffic conditions during each hour of the day. Once this has been determined it is used to calculate an impact distance from the link for each hour of the day. This impact distance is the distance at which the appropriate noise standard is met; it is multiplied by the link length to determine the area in which the previously specified L_{10} dBA level is exceeded. Although the dosages calculated in this fashion only explicitly address roadway noise, adjustments to the noise propagation model were made to account for other types of

noise discussed in Chapter IV. Information on present and projected airport noise impact was considered in the final noise dosage calculations. Significant additional noise impact could affect the actual dosage in a few RPDs beyond the adjustments made. In any case, the relative ranking of noise exposure would not be strongly affected by this fact.

Thus the person-hour dosage is calculated using the following equation:

$$\text{DOSAGE (CLASS)} = \text{PROB (CLASS)} \times \text{LL} \times \text{D (CLASS)} \times \text{DIST (N)} \times 2 \times \text{FACT (CLASS, N)}$$

where:

CLASS	=	either Residential, Institutional, Industrial or Commercial
PROB	=	the probability that the class under consideration is close to the major arterial and freeways in the RPD that this link is in (Table V-3)
LL	=	the link length from the traffic data
D (Class)	=	the density of the class in the particular RPD for the specific alternate under consideration with D_R , D_C , D_{IS} , D_{ID} .
DIST (N)	=	the distance from the link for the hour under construction
2	=	a factor allowing equal consideration of each side of the link
FACT (CLASS N)	=	a factor which reflects for each class and every hour of the day the likelihood of being in the impacted area.

Each of these 24-hour person dosages are summed and the next link is read and analyzed.

When all the links in an alternative have been analyzed, the person-hour dosages are found at the RPD level. The program then sums these RPD dosages to provide community noise dosages by jurisdiction.

TABLE V-3

BALTIMORE REGION -- JURISDICTION TO RPD CONVERSION TABLE

Jurisdiction	RPD
Baltimore City	109-110-111-116- 117-118-119-120- 123-124 101-102-107-108 103-104-105 106-112-113 114-115-122 125-126 121
Suburban Counties in Baltimore Region	
Anne Arundel County	201-202-203 205-208-209-210 204-206-207 211-212-213-214- 215 216-217
Baltimore County	301-302 303-306-311-312 304-305-309-310 307-313 308-314-315 316-317-318-320- 321-326 322-327-328-329- 330-331 319-323-324-325

TABLE V-3 -- Continued

Jurisdiction	RPD
Carroll County	401-402-403 404-405-406
Harford County	501-502-503 504-505-506-507
Howard County	601-602-604 603-605-606-607

VI. RESULTS AND EVALUATION

RESULTS

The noise impact in the Baltimore region for the land use-transportation alternatives in design years 1980 and 1995 was expressed in person-hours dosages and per capita dosages, reflecting the Federal Highway Administration PPM 90-2 guidelines. These land use transportation alternatives were ranked according to each of the two noise dosage criteria within each design year. This analysis was done in four land use classes (residential, institutional, commercial and industrial) for each of the following geographical areas:

- Total area inside BMATS
- Baltimore City
- Ann Arundel County inside BMATS
- Baltimore County inside BMATS
- Howard County inside BMATS

Each pair of class and jurisdiction is considered to define a population segment. Both indices are objective indicators of noise impact. However, since the population size varies between alternatives, the per capita index is more descriptive of the noise levels to which an individual will be exposed. For example, two population segments with similar noise levels will have similar per capita indices, although the larger population segment will have a larger total dosage. For this reason, per capita dosage will be used in most of the following discussion. (A detailed explanation of person-hours and per capita dosage is included in Chapter III. Table VI-I lists the results of the community dosage calculated for each alternative.

One salient feature of the present and projected noise dosage is that the residential per capita noise dosage in Baltimore City is an order of magnitude greater than dosages in the rest of the BMATS area. However, the per capita commercial, institutional, and industrial dosages are approximately the same throughout the entire study area. The collection of intense commercial, institutional, and industrial development near roadways both inside and outside of Baltimore City account for this similarity. In contrast, the residential areas outside the City are generally removed from the roadway and consequently receive a considerably smaller dosage of noise.

TABLE VI-1
COMMUNITY DOSAGE INSIDE BMATS

JURISDICTION	KEY	RESIDENTIAL IMPACT	RANK ORDER	COMMERCIAL IMPACT	RANK ORDER	INSTITUTIONAL IMPACT	RANK ORDER	INDUSTRIAL IMPACT	RANK ORDER
BALTIMORE CITY									
Alt. 1 (1970)	T	314946. 0.340		118897. 1.753		611818. 1.661		137222. 1.338	
Alt. 3 (1980)	T	305363.	3	130781.	3	895813.	2	171181.	3
3-A System	P	0.347	2	2.077	3	1.965	2	1.835	3
Alt. 4 (1980)	T	305333.	2	134924.	2	3433182.	3	162035.	2
3A W/O Ft. McHenry	P	0.348	3	2.015	2	3.109	3	1.569	2
Alt. 5 (1980)	T	289028.	1	121714.	1	594102.	1	149331.	1
No. 3-A	P	0.339	1	1.874	1	1.738	1	1.468	1
Alt. 6 (1995)	T	311437.	2	171854.	3	856357.	4	192970.	3
3-A and GDP	P	0.344	2	2.200	3	1.993	3	1.675	3
Alt. 7 (1995)	T	280804.	1	145301.	1	715176.	2	163292.	1
GDP System	P	0.326	1	1.984	1	1.763	2	1.516	1
Alt. 8 (1995)	T	380693.	4	180751.	4	841518.	3	199754.	4
3-A System	P	0.378	4	2.237	4	1.994	4	1.700	4
Alt. 0 (1995)	T	346809.	3	148788.	2	713791.	1	167714.	2
No 3-A	P	0.355	3	1.988	2	1.759	1	1.543	2
ANNE ARUNDEL CO									
Alt. 1 (1870)	T	2826.		25498.		48125.		4052.	
	P	0.015		1.861		0.506		0.260	
Alt. 3 (1980)	T	6048.	1	28872.	1	71773.	2	4569.	1
3-System	P	0.023	1	2.032	1	0.528	1	0.282	1
Alt. 4 (1980)	T	8214.	2	29388.	2	72313.	3	4597.	2
3A W/O Ft. My	P	0.024	2	2.048	2	0.532	3	0.283	2
Alt. 5 (1980)	T	8581.	3	31523	3	71588.	1	4733.3	3
No 3-A	P	0.025	3	2.081	3	0.530	2	0.288	3
Alt. 6 (1995)	T	12820.	4	54872.	3	80309	4	8043.	3
3A and GDP	P	0.034	4	2.488	4	0.518	3	0.433	4
Alt. 7 (1995)	T	11813.	3	58520.	4	85752.	3	8070.	4
GDP System	P	0.032	3	2.412	3	0.542	4	0.415	3

Table VI-1, Continued

JURISDICTION	KEY	RESIDENTIAL IMPACT	RANK ORDER	COMMERCIAL IMPACT	RANK ORDER	INSTITUTIONAL IMPACT	RANK ORDER	INDUSTRIAL IMPACT	RANK ORDER
Alt. 6 (1995) 3A System	T P	7597. 0.024	2 2	38221. 1.844	2 1	80793. 0.513	2 2	5074. 0.309	1 2
Alt. 9 (1995) No 3-A	T P	7145. 0.024	1 1	37746. 1.981	1 2	75774. 0.487	1 1	5940. 0.303	2 1
BALTIMORE CO Alt. 1 (1970)	T P	11000. 0.018		59518. 1.389		62874. 0.286		42593. 0.640	
Alt. 3 (1980) 3A System	T P	21877. 0.030	3 3	73248. 1.625	1 1	91159. 0.323	2 2	58513. 0.811	1 1
Alt. 4 (1980) 3A W/O Ft. My	T P	21509. 0.030	1 1	73952. 1.631	2 3	91566. 0.324	3 3	58944. 0.015	2 2
Alt. 5 (1980) No 3-A	T P	21803. 0.030	2 2	76077. 1.838	3 2	88018. 0.322	1 1	59785. 0.622	3 3
Alt. 6 (1995) 3A and GDP	T P	44977. 0.050	4 4	140841. 2.243	3 4	128325. 0.375	4 4	73986. 0.911	3 3
Alt. 7 (1995) GDP System	T P	40955. 0.047	3 3	144987. 2.198	4 3	128108. 0.371	3 3	75579. 0.920	4 4
Alt. 8 (1995) 3A System	T P	33290. 0.040	2 2	92827. 1.849	2 2	102717. 0.315	2 2	67403. 0.848	2 2
Alt. 9 (1995) No 3-A	T P	28200. 0.037	1 1	92650. 1.614	1 1	98457. 0.310	1 1	60481. 0.030	1 1
HOWARD CO Alt. 1 (1970)	T P	110. 0.002		2045. 0.795		2529. 0.103		2499. 0.510	
Alt. 3 (1980) 3A System	T P	1990. 0.013	2 2	7014. 0.005	1 1	12562. 0.159	2 1	23461. 1.244	1 1
Alt. 4 (1980) 3A W/O Ft. My	T P	1991. 0.013	3 3	7094. 1.011	2 2	12619. 0.160	3 3	23644. 1.251	2 3
Alt. 5 (1980) No 3-A	T P	1942. 0.013	1 1	7502. 1.014	3 3	12225. 0.159	1 2	24157. 1.248	3 3

Table VI-1, Continued

JURISDICTION	KEY	RESIDENTIAL IMPACT	RANK ORDER	COMMERCIAL IMPACT	RANK ORDER	INSTITUTIONAL IMPACT	RANK ORDER	INDUSTRIAL IMPACT	RANK ORDER
Alt. 6 (1995) 3A and GDP	T P	5683. 0.021	4 4	17069. 1.328	3 3	10078. 0.174	4 3	36352. 1.251	3 3
Alt. 7 (1995) GDP System	T P	5370. 0.020	3 3	19341. 1.368	4 4	16503. 0.177	3 4	38993. 1.291	4 4
Alt. 6 (1995) 3A System	T P	3889. 0.016	2 2	11898. 1.088	1 1	14310. 0.153	2 2	24679. 0.859	2 2
Alt. 9 (1995) No 3-A	T P	3700. 0.016	1 1	12108. 1.087	2 2	13753. 0.153	1 1	24420. 0.819	1 1
INSIDE BELTWAY									
Alt. 1 (1970)	T P	322914. 0.259		158611. 1.727		870065. 1.374		164502. 1.369	
Alt. 3 (1980) 3A System	T P	316042. 0.256	3 2	177854. 2.017	3 3	770900. 1.598	2 2	208350. 1.075	3 3
Alt. 4 (1980) 3A W/O Ft. My	T P	315953. 0.257	2 3	173477. 1.873	2 2	3500093. 2.047	3 3	200232. 1.622	2 2
Alt. 5 (1980) No 3-A	T P	299994. 0.249	1 1	182247. 1.074	1 1	868656. 1.431	1 1	187525. 1.542	1 1
Alt. 8 (1995) 3A and GDP	T P	325154. 0.252	2 2	222191. 2.215	4 4	847453. 1.624	4 4	237416. 1.723	3 3
Alt. 7 (1995) GDP System	T P	293738. 0.236	1 1	208027. 2.085	2 2	805412. 1.446	2 2	209777. 1.602	1 1
Alt. 8 (1995) 3A System	T P	403399. 0.283	4 4	231531. 2.157	3 3	925745. 1.619	3 3	243099. 1.741	4 4
Alt. 9 (1985) No 3-A	T P	359328. 0.203	3 3	200804. 1.858	1 1	784776. 1.444	1 1	210712. 1.084	2 2

Table VI-1, Continued

JURISDICTION	KEY	RESIDENTIAL IMPACT	RANK ORDER	COMMERCIAL IMPACT	RANK ORDER	INSTITUTIONAL IMPACT	RANK ORDER	INDUSTRIAL IMPACT	RANK ORDER
OUTSIDE BELTWAY									
Alt. 1 (1970)	T	6160.		47344.		56263.		21964.	
	P	0.012		1.374		0.254		0.319	
Alt. 3 (1980)	T	19235.	2	71042.	1	100408.	2	49460.	1
3-A System	P	0.024	2	1.585	1	0.272	2	0.565	1
Alt. 4 (1980)	T	19175.	1	71881	2	100784.	3	49490.	2
3A W/O Ft.Mc	P	0.024	1	1.572	3	0.273	3	0.565	2
Alt. 5 (1980)	T	19360.	3	74569.	3	98162.	1	50483.	3
No 3-A	P	0.025	3	1.566	2	0.271	1	0.570	3
Alt. 6 (1985)	T	49764.	4	152546.	3	142410.	4	74033.	3
3-A and GDP	P	0.043	4	2.141	4	0.313	3	0.690	3
Alt. 7 (1995)	T	45205.	3	15732.	4	130280.	3	97659.	4
GDP System	P	0.040	3	2.087	3	0.314	4	0.697	4
Alt. 8 (1995)	T	31351.	2	92164.	2	113593.	2	54612.	2
3-A System	P	0.032	2	1.501	1	0.287	2	0.522	2
Alt. 9 (1995)	T	27527.	1	80487.	1	106999.	1	53043.	1
No 3-A	P	0.029	1	1.508	2	0.250	1	0.507	1
TOTAL IMPACT									
Alt. 1 (1970)	T	320982.		205955.		726347.		186466.	
	P	0.186		1.831		1.024		0.907	
Alt. 3 (1980)	T	335278.	3	248895.	3	871308.	2	257025.	3
3-A System	P	0.188	2	1.883	3	1.023	2	1.216	3
Alt. 4 (1980)	T	335120.	2	245258.	2	3609644.	3	249821.	2
3A W/O Ft.Mc	P	0.186	3	1.838	2	2.253	3	1.183	2
Alt. 5 (1980)	T	319353.	1	236818.	1	768812.	1	238007.	1
No 3-A	P	0.160	1	1.765	1	0.924	1	1.132	1
Alt. 6 (1985)	T	374017.	2	384737.	4	1080870.	4	311951.	4
3-A and GDP	P	0.153	2	2.185	4	1.049	4	1.271	4
Alt. 7 (1995)	T	330942.	1	365159.	3	943700.	2	206536.	2
GDP System	P	0.143	1	2.074	3	0.946	2	1.189	2
Alt. 8 (1995)	T	434650.	4	323695.	2	1039338.	3	297711.	3
3-A System	P	0.180	4	1.918	2	1.041	3	1.219	3
Alt. 9 (1995)	T	366855.	3	281201.	1	001775.	1	204555.	1
No 3-A	P	0.168	3	1.791	1	0.934	1	1.113	1

T = Person-Hour Impact
P = Per Capita Impact

In general, the per capita residential dosage has been considered the most representative index of noise impact.

BMATS Area

The results concerning the total study area inside BMATS will be discussed first. The per capita dosage often varies only by a few percentage points among the alternatives in a study year. In the discussion of the relative ranking of alternatives which follows, these small differences should be considered. Alternative 1 (1970) levels are used as a reference to the 1980 and 1995 alternatives. The short-term (1980) effects in the BMATS area indicate that Alternative 5 (no 3-A) is best for all four classes. This top-ranking of Alternative 5 (no 3-A) is almost universal for all the population segments represented in Table VI-1. The relative ranking of Alternative 3 (complete 3-A) and 4 (3-A less Ft. McHenry Crossing) varies depending on which class is examined, but in most cases, the absolute difference is small.

The long-term (1995) effects indicate that Alternative 7 (no 3-A, all other GDP improvements) produces the least per capita residential noise dosage. This alternative is ranked second for institutional and industrial per capita dosage and third for commercial per capita dosage. Alternative 9 (no 3-A, no other GDP improvements) is ranked first for all classes except for residential where it is third. Alternative 6 (3-A, GDP improvement) is ranked fourth in all classes except for residential where it is ranked second. The high ranking of Alternatives 7 and 9 indicates the long term effects of not building the 3-A system on noise impact. The implications of building the GDP highways are mixed, based on the total BMATS dosage; however, as will be shown in subsequent sections, the area outside the Baltimore Beltway (I-695) is exposed to more noise if the GDP is built and less if it is not. The causes of the dosage increase are complex; but, in general, the development produces more traffic and higher densities. Land use controls, which would offset this density growth, and traffic regulations, which would reduce the production of noise, could reduce the noise dosage.

Baltimore City

For Baltimore City, in the short term (1980), Alternative 5 (no 3-A) ranks the best of all the classes. The relative ranking between alternatives 3 (complete 3-A) and 4 (3-A, less Ft. McHenry Crossing) varies among the classes and the absolute values are very close. Alternative 3 ranks slightly ahead of Alternative 4 for per person residential dosage.

With the exception of the institutional class, Alternative 7 (no 3-A, all GDP improvements) has the least noise impact in 1995. This indicates the construction of the GDP system pulls both traffic and land development outside the City, resulting in a lesser dosage there.

Alternative 6 (3-A, all GDP improvements) ranks second in the residential class per capita dosage and third in all other classes. Alternative 8 (3-A, no other GDP improvements) ranks the worst in all four classes; this indicates the traffic and land use implications of building the 3-A system only results in the highest per capita dosage in Baltimore City.

Other Jurisdictions

For Anne Arundel County, the short-term (1980) effects indicate that Alternative 3 (complete 3-A) would produce the least noise dosage for all the classes. For most of the classes, Alternative 4 produces slightly less impact.

The long-term alternatives (1995) rate Alternative 9 (no 3-A, no other GDP improvements) as the best choice for all but commercial classes. Alternatives 6 (complete 3-A and GDP improvements) and 7 (no 3-A, all other GDP improvements) are last or second to the last in all classes. The absolute numbers indicate that the substantial controlling factor is the construction of the GDP highways while the influence of the 3-A system is considerably less. These facts indicate the relative noise effects of building the GDP system in Anne Arundel County.

Outside BMATS

The community exposure to noise outside BMATS was analyzed for each of the 24 RPDs. Lack of detailed input data necessary for the community dosage noise prediction computer program used inside BMATS necessitated a different approach to analyze noise dosages outside BMATS. A more general approach was taken, and noise levels were predicted 100 feet from a typical roadway. A discussion of this approach is included in Appendix E.

A computer program was developed to predict noise levels 100 feet from a typical roadway in each RPD. The input requirements are: area of the RPD, street miles and vehicle miles of travel. Results (Table VI-2) were summed according to political jurisdictions: Anne Arundel County,

Baltimore County, Carroll County, Harford County and Howard County. The background traffic noise 100 feet from the roadway is low in all jurisdictions in all alternatives. With the exception of Howard County, in which the short-term (1980) effect of no development results in a small peak in the noise levels, the alternatives do not vary appreciably.

The Contribution of Roadway Noise to Background Levels

The calculation of roadway noise to the general background noise levels has been calculated in a manner similar to that described in Chapter III. Instead of calculating the noise level at a fixed distance of 100 feet, an algorithm was developed to calculate a "typical distance" from the road. The following equation was used to calculate the "typical distance" for each RPD.

$$d = \frac{A}{2L}$$

where:

A = Area of RPD

L = Total length of road in the RPD

d = "Typical" distance

This equation was developed on the hypothesis that a strip-width of twice the typical distance (d) surrounding the road should equal the area of the RPD.

Table VI-2 shows the result of this calculation during the peak traffic hour. It should be noted that these values assume that the nearest road to the typical location is not shielded by the terrain or other features. Under these latter circumstances, levels 10-15 dBA less are realized. As can be seen from the values on this table, the roadway contribution is very often of the order 40 dBA or less. In this case, other sound sources are also significant contributors to the background noise. The field measurements program in Chapter IV indicates that non-roadway daytime sources usually result in noise levels in excess of 40 dBA. In examining the relationship between roadway sources and other sources, the reader should keep in mind the logarithmic nature of the dBA scale. Thus, a 40-dBA background noise and a 40-dBA roadway noise level do not produce an 80 dBA noise level. The combination is approximately 43 dBA.

TABLE VI-2

CONTRIBUTION OF ROADWAY NOISE TO BACKGROUND LEVELS (L_{10} dBA)

JURISDICTION	1980			1995				
	1970 ALT.1	ALT.3	ALT.4	ALT.5	ALT.6	ALT.7	ALT.8	ALT.9
INSIDE BMATS								
BALTIMORE CITY	55.1	52.7	50.9	49.6	49.1	48.1	48.3	47.4
ANNE ARUNDEL COUNTY	48.7	47.1	45.4	44.3	45.0	44.1	42.9	42.1
BALTIMORE COUNTY	48.9	47.0	45.2	44.0	44.1	43.2	42.5	41.7
HOWARD COUNTY	44.3	45.7	44.0	40.4	45.0	52.1	43.1	42.4
OUTSIDE BMATS								
ANNE ARUNDEL COUNTY	46.5	44.5	43.1	42.0	43.4	42.6	40.7	40.1
BALTIMORE COUNTY	36.7	33.7	32.0	30.8	30.6	29.8	27.9	27.2
CARROLL COUNTY	40.9	38.8	37.0	35.9	36.5	35.7	33.2	32.5
HARFORD COUNTY	41.8	40.0	38.0	36.8	36.7	35.9	35.0	34.3
HOWARD COUNTY	36.8	34.3	32.6	28.6	32.6	31.8	31.0	30.3

Note: In most cases, levels below 40 dBA are masked by other sounds

Background roadway noise levels outside the BMATS are very low and will be masked by other sources for all the alternatives. The roadway source noise and "other" noise sources inside BMATS are comparable in intensity over most of the area. An exception is Baltimore City, where for all the alternatives roadway noise is a significant factor. In the short-term (1980) Alternative 3 (complete 3-A) has the greatest noise level in Baltimore City, although it is only 3 dBA below the lowest value; this shows the relative difference among alternatives is small. The long term (1995) has an even narrower spread (2.2 dBA) with Alternative 6 (3-A; and GDP improvement) producing the highest noise level. As previously discussed, most people cannot distinguish sound levels differing by only 1 or 2 dBA.

Transit Stations and Other Noise Sources

Other sources of noise in the study area have been identified from the field program discussed in Chapter IV. These sources have been considered in the previously described dosage calculation. Noise from the planned rail mass transit system can be generated by two sources: the sounds generated by the rail system, and bus and auto activity at the transit stations. The available information indicates rail system noise will not produce significant noise impact. (8) At most of the stations, several hundred bus trips a day are expected. Although the bus traffic is small compared to the total truck traffic, in the vicinity of the station, this additional traffic can be significant. Proper design of bus routes and selection of buses will mitigate against this noise impact. In addition, the available information on the transit lines indicates that the system itself will not substantially contribute to exceeding the discussed L_{10} levels. Although detailed information was not available, the present rail system, the jet aircraft activity, and industrial activities add noticeably to the noise climate near these facilities. Careful control of both new facilities and development near these facilities will serve to mitigate against additional noise intrusion.

CONCLUSIONS

The basic results of the noise analysis indicate, in general, that construction of the highways produces more per person noise dosage as well as total person hours. These facts are due to both the land use patterns and traffic generated by the highway. However, controlled land use growth and proper traffic regulations can reduce the noise dosage. Specific measures would include:

1. Traffic controls (e.g., speed control, synchronization of traffic lights, widening of streets, etc.) which would minimize the generation of vehicular noise and could reduce sound levels 5-10 dBA.
2. The assignment of bus and truck routes to fewer streets will reduce noise levels 5-10-dBA along corridors where trucks and buses can be eliminated.
3. Land use controls (e.g., location of roadside development, development designs, construction materials, etc.) can significantly reduce actual noise exposure of people.
4. The installation of noise abatement devices over sensitive segments of the GDP Improvement Plan can reduce noise levels 10-15 dBA in the vicinity of the roadway. Such devices could be similar to those planned for the 3-A system.

The study indicates the major dosage to occur during the midday and early evening; therefore, abatement procedures should specifically address these impact hours. In addition, residential areas of the City of Baltimore are exposed to considerably more noise than outlying districts. Noise abatement should also address City residences.

The noise dosage has been based on land use characteristics evaluated on a RPD level. A more detailed and sensitive evaluation of the noise dosage should perhaps be performed by inputting the adjacent land use associated with each highway link. At present, traffic conditions for each link in the network is available but actual land use data associated with each link has not been developed; therefore, a link sensitive noise analysis was not done.

General Comments

Based on the previous discussion, the general features of the long term trends established from the examples can be established for the region and as shown in Table VI-I. Figures VI-1 through VI-8 indicate these results on a map of the region.

1. The noise dosage in the counties increases with the construction of the GDP improvements.

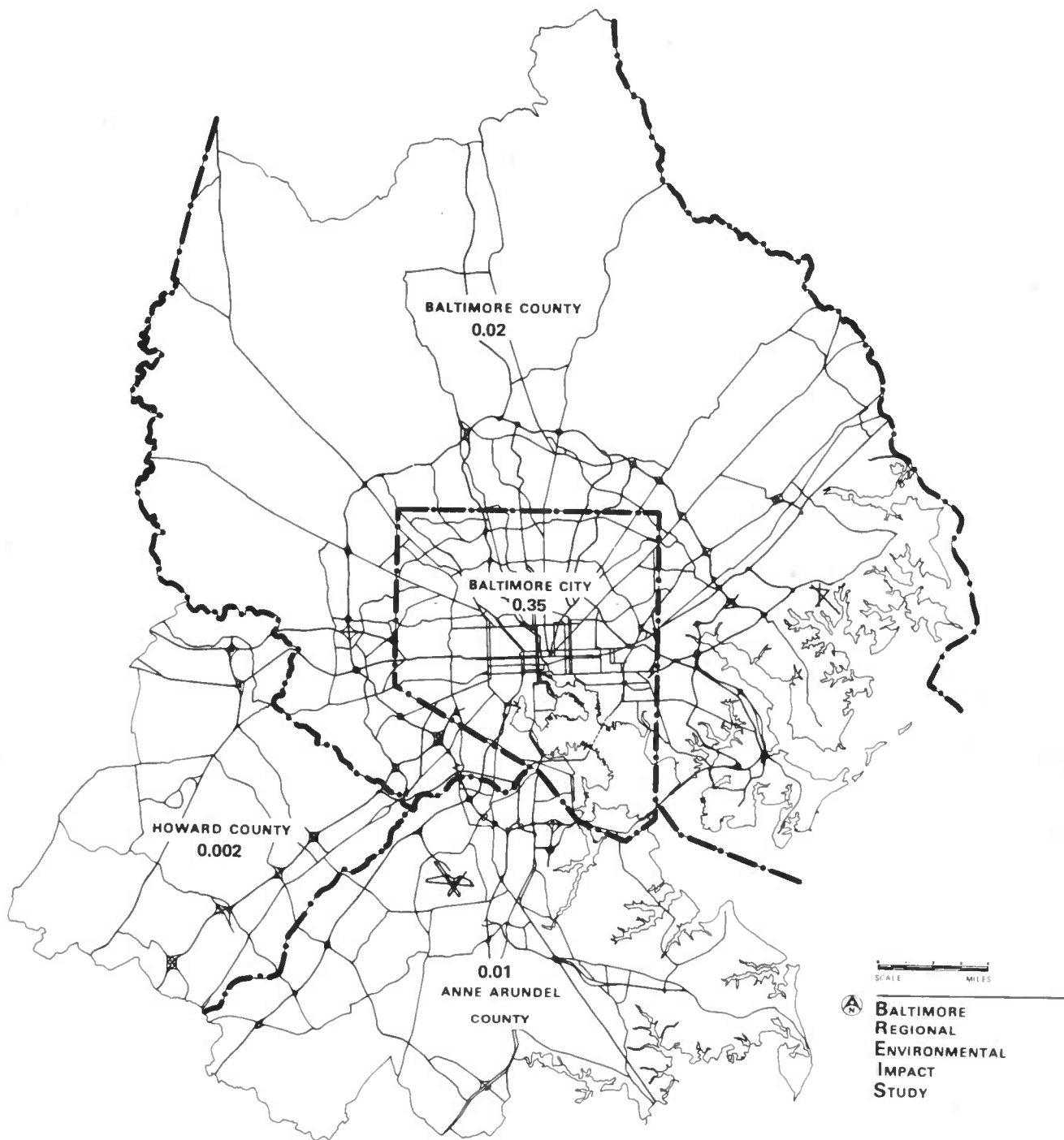


FIGURE VI-1. ALTERNATIVE 1: RESIDENTIAL PER-PERSON DOSAGE

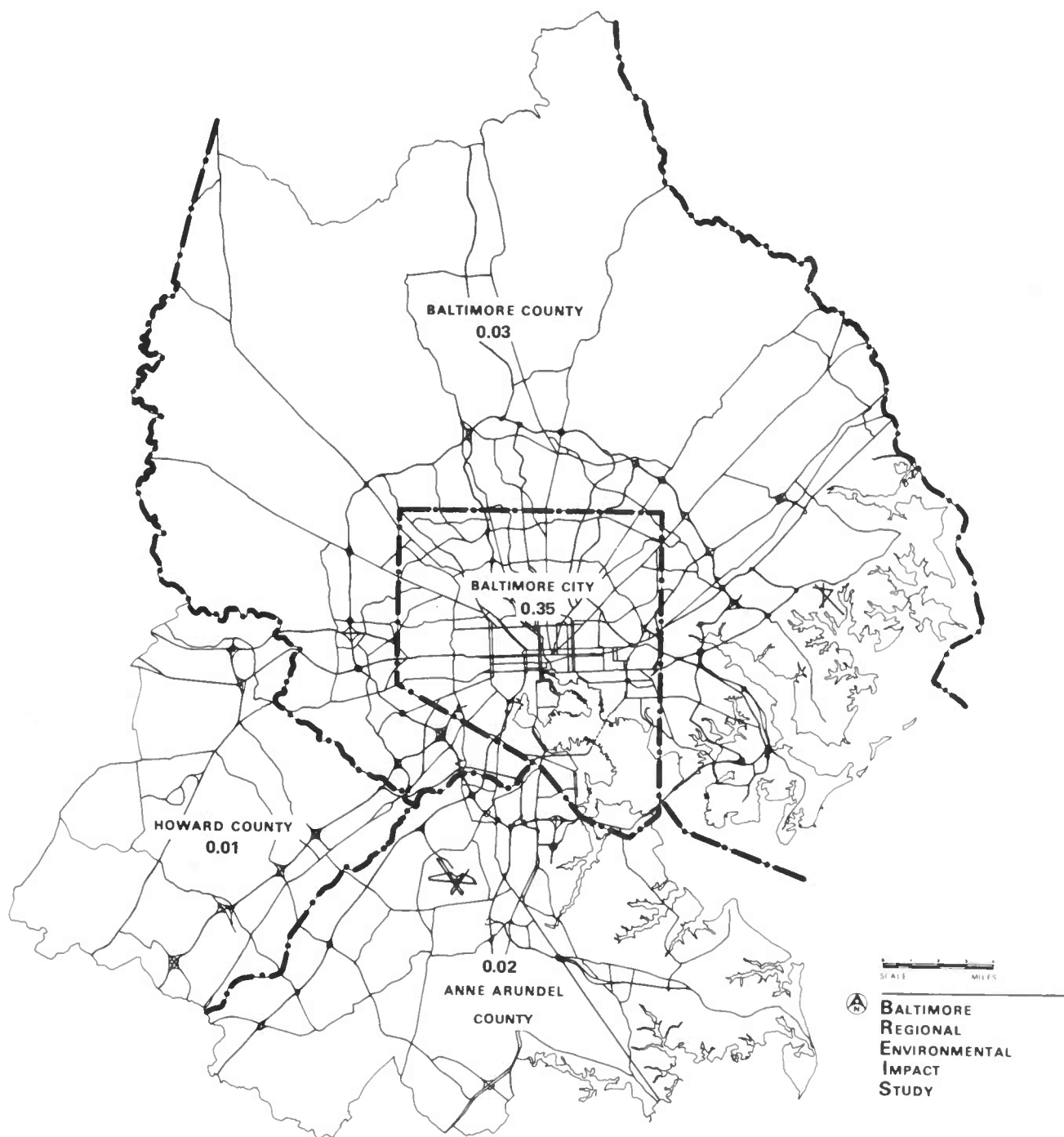


FIGURE VI-2. ALTERNATIVE 3: RESIDENTIAL PER-PERSON DOSAGE

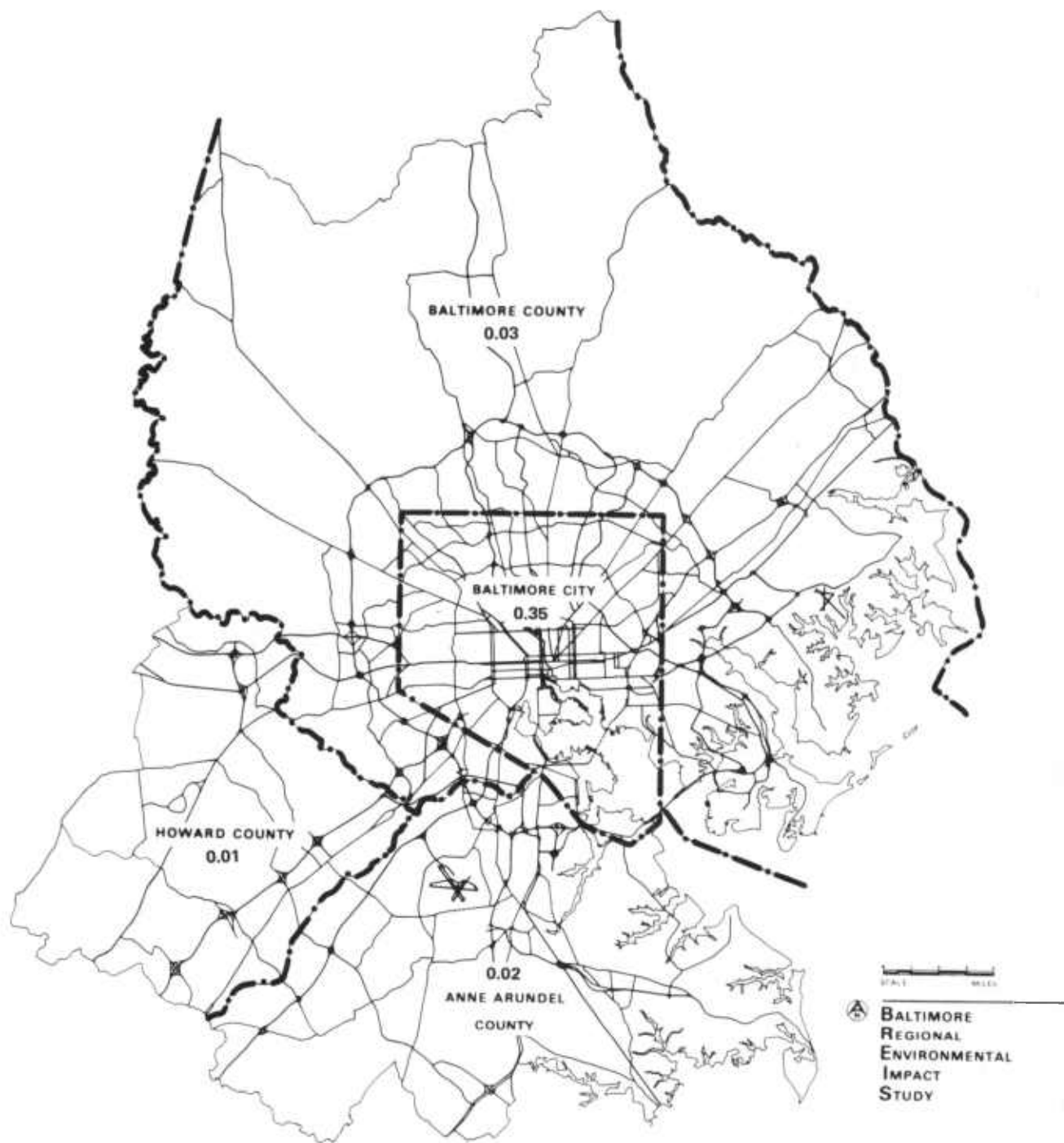


FIGURE VI-3. ALTERNATIVE 4: RESIDENTIAL PER-PERSON DOSAGE

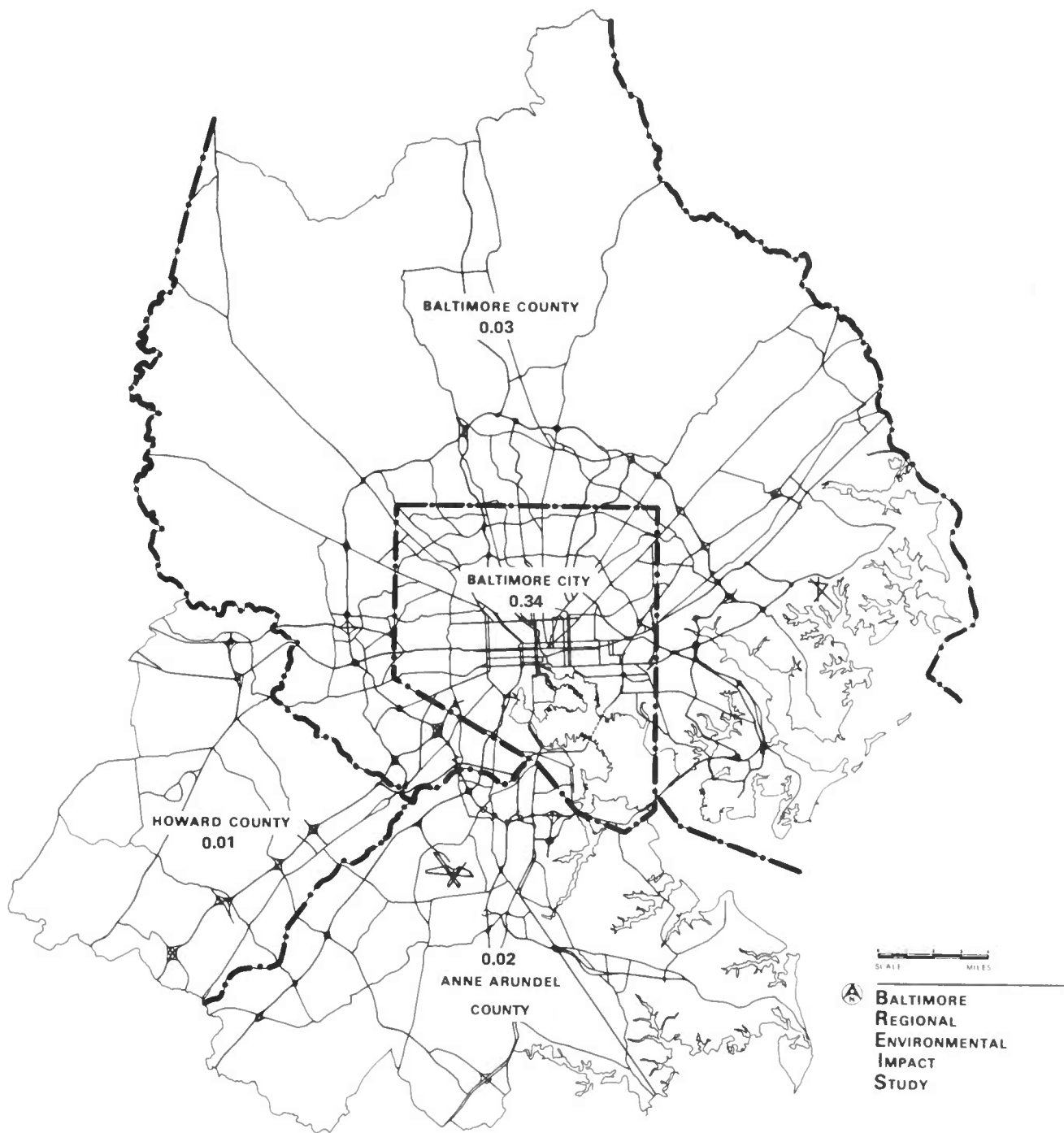


FIGURE VI-4. ALTERNATIVE 5: RESIDENTIAL PER-PERSON DOSAGE

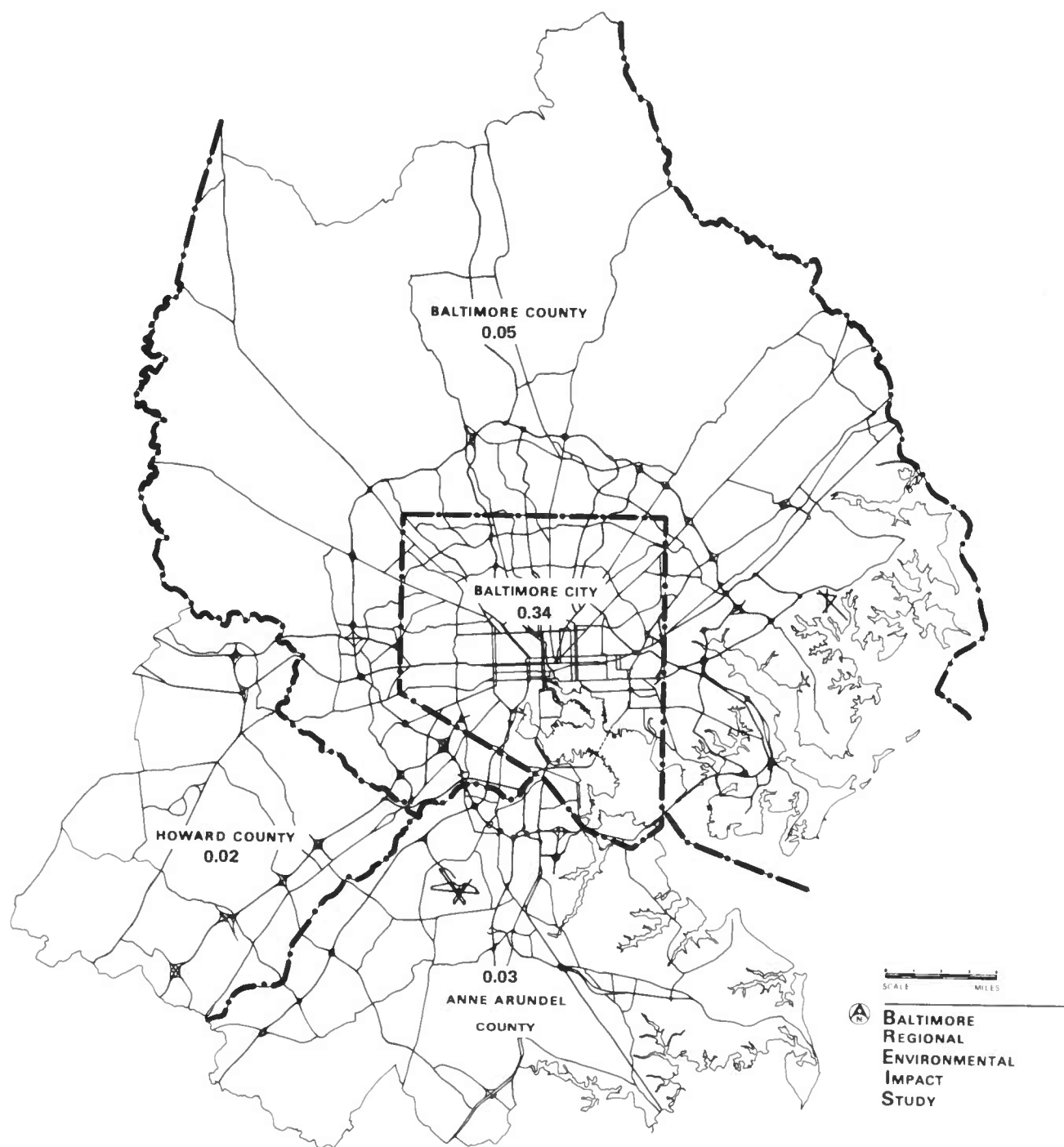


FIGURE VI-5. ALTERNATIVE 6: RESIDENTIAL PER-PERSON DOSAGE

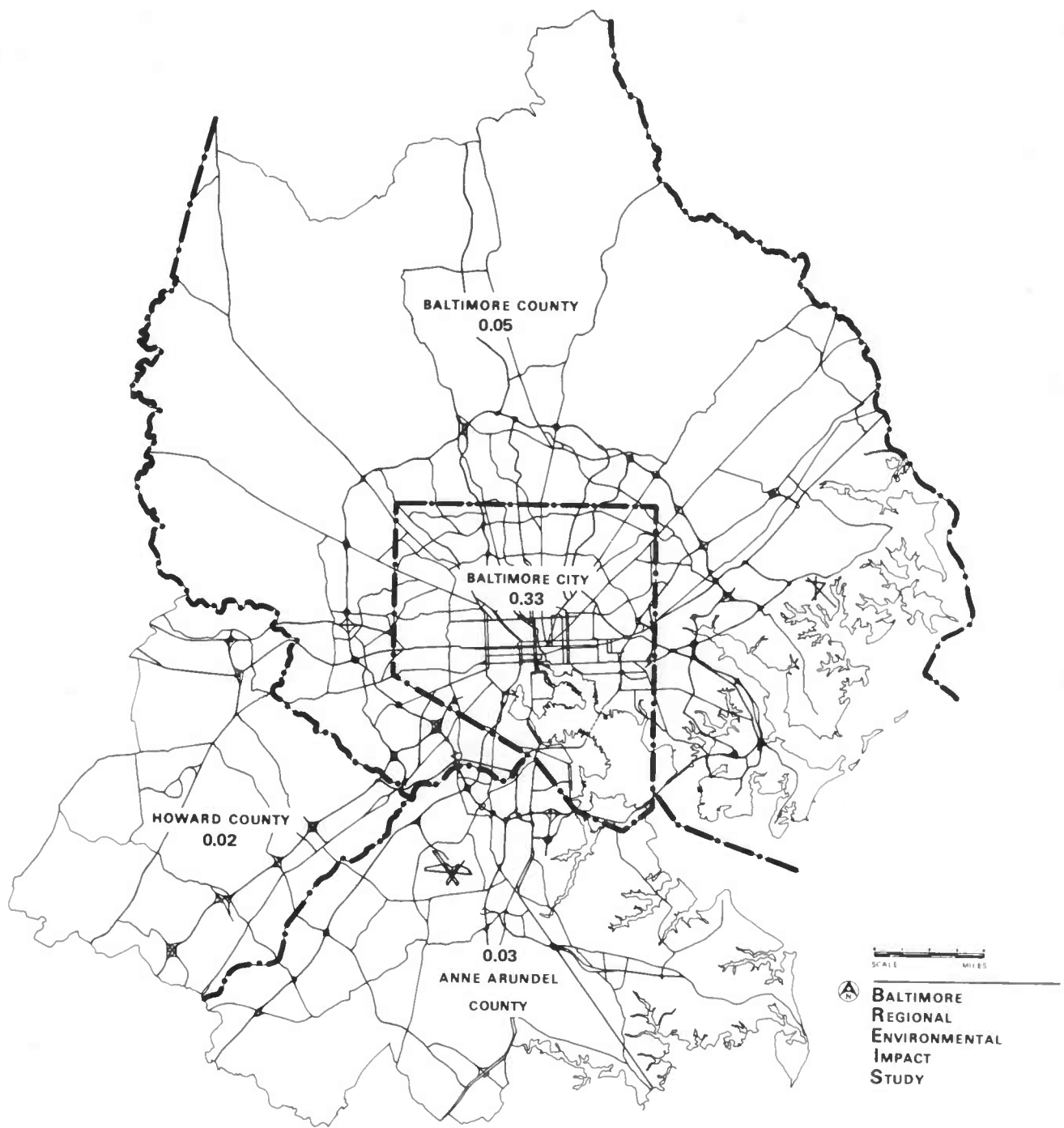


FIGURE VI-6. ALTERNATIVE 7: RESIDENTIAL PER-PERSON DOSAGE

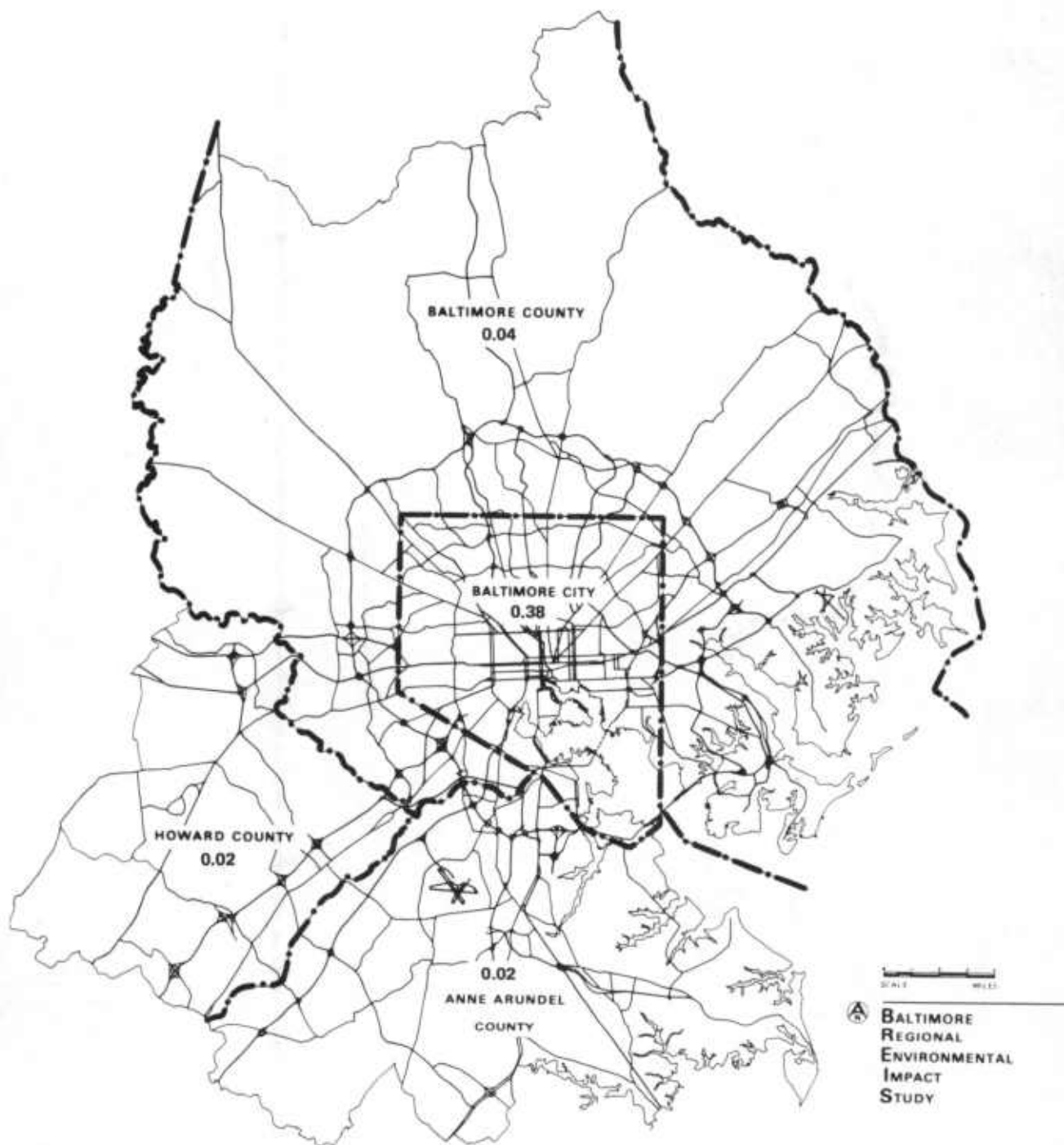


FIGURE VI-7. ALTERNATIVE 8: RESIDENTIAL PER-PERSON DOSAGE

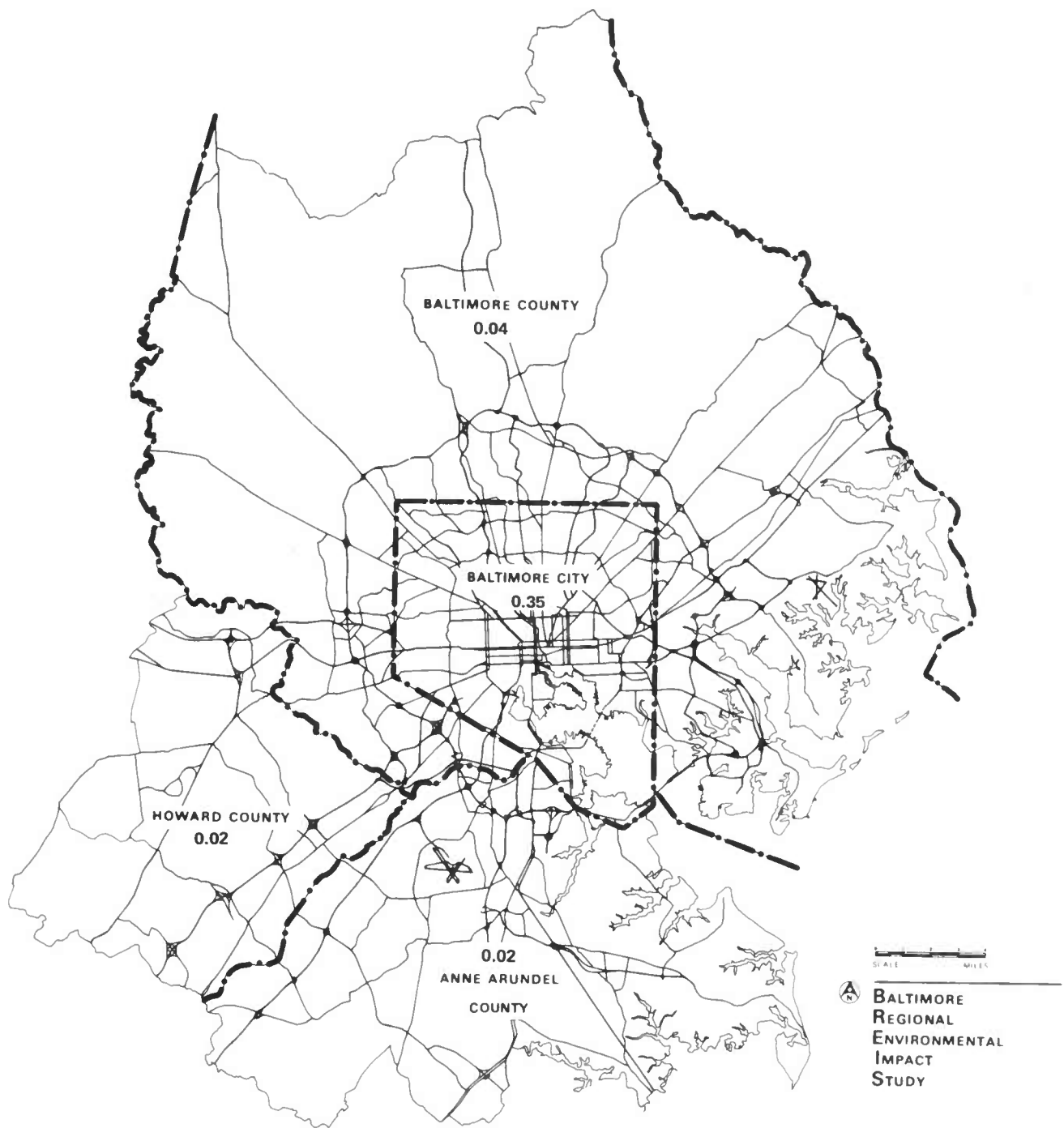


FIGURE VI-8. ALTERNATIVE 9: RESIDENTIAL PER-PERSON DOSAGE

2. Constructing the GDP highway improvements primarily influences the per capita dosage of noise in the outlying districts, although it does produce some improvement in per capita dosage of noise inside the City of Baltimore.
3. Construction of the 3-A system increases the noise dosage inside the City of Baltimore.
4. Construction of the 3-A system primarily influences the per capita noise dosage in Baltimore City, while producing some improvements in the outlying districts.

REFERENCES

1. Memoranda to Urban Design Concept Associates, dated, April 13, June 23, June 26, June 26, July 17, October 7, October 27, November 24, December 10, December 23, December 30 and December 30, 1970.
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7. Colonel Scott, Friendship Airport, per telephone conversation, June 1973.
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APPENDICES

APPENDIX A

The following is a reproduction of the Federal Highway Administration
Policy and Procedure Memorandum 90-2.

POLICY AND PROCEDURE MEMORANDUM

Transmittal 279

90-2

February 8, 1973

NOISE STANDARDS AND PROCEDURES

- Par. 1. Purpose
2. Authority
3. Noise Standards
4. Applicability
5. Procedures

Appendix A - Definitions

Appendix B - Noise Standards

1. PURPOSE

To provide noise standards and procedures for use by State highway agencies and the Federal Highway Administration (FHWA) in the planning and design of highways approved pursuant to Title 23, United States Code, and to assure that measures are taken in the overall public interest to achieve highway noise levels that are compatible with different land uses, with due consideration also given to other social, economic and environmental effects.

2. AUTHORITY

Sections 109(h) and (i), Title 23, United States Code, state that guidelines shall be promulgated "to assure that possible adverse economic, social, and environmental effects relating to any proposed project on any Federal-aid system have been fully considered in developing such project, and that the final decisions on the project are made in the best overall public interest, taking into consideration the need for fast, safe and efficient transportation, public services, and the costs of eliminating or minimizing such adverse effects and the following: (1) air, noise, and water pollution; . . ." and that "The Secretary, after consultation with appropriate Federal, State, and local officials, shall develop and promulgate standards for highway noise levels compatible with different land uses and after July 1, 1972, shall not approve plans and specifications for any proposed project on any Federal-aid system for which location approval has not yet been secured unless he determines that such plans and specifications include adequate measures to implement the appropriate noise level standards."

3. NOISE STANDARDS

a. Noise standards are appended as Appendix B. Federal Highway Administration encourages application of the noise standards at the earliest appropriate stage in the project development process.

b. There may be sections of highways where it would be impossible or impracticable to apply noise abatement measures. This could occur where abatement measures would not be feasible or effective due to physical conditions, where the costs of abatement measures are high in relation to the benefits achieved, or where the measures required to abate the noise condition conflict with other important values, such as desirable esthetic quality, important ecological conditions, highway safety, or air quality. In these situations, highway agencies should weigh the anticipated noise impacts together with other effects against the need for and the scope of the project in accordance with other FHWA directives (PPM's 20-8, 90-1, and 90-4).

4. APPLICABILITY

In order to be eligible for Federal-aid participation, all projects to which the noise standards apply shall include noise abatement measures to obtain the design noise levels in these standards unless exceptions have been approved as provided herein.

a. Projects to which noise standards apply. The noise standards apply to all highway projects planned or constructed pursuant to Title 23, United States Code, except projects unrelated to increased traffic noise levels, such as lighting, signing, landscaping, safety and bridge replacement. Pavement overlays or pavement reconstruction can be considered as falling within this category unless the new pavement is of a type which produces more noise than the type replaced.

b. Approvals to Which Compliance with Noise Standards Is Prerequisite

(1) Projects for which location was approved prior to July 1, 1972: Compliance

with noise standards shall not be a prerequisite to any subsequent approval provided design approval is secured prior to July 1, 1974. If design approval is not secured for such a project prior to July 1, 1974, compliance with the noise standards shall be a prerequisite to securing both design approval and approval of plans and specifications. However, such compliance shall not be a basis for requiring reconsideration of the highway location or any other approval action which has previously been taken for such projects.

(2) Projects for which location is approved on or after July 1, 1972:

(a) If location approval was requested on or before December 31, 1972, compliance with the noise standards shall be a prerequisite to obtaining design approval and approval of plans and specifications. Compliance with the noise standards shall not be a prerequisite to obtaining location approval, nor shall such compliance be a basis for requiring reconsideration of the highway location or any other approval action which has previously been taken for such projects. Combined location and design approval shall be handled in the same manner as separate design approval.

(b) If location approval is requested after December 31, 1972, compliance with the noise standards shall be a prerequisite to obtaining location and design approvals as well as approval of plans and specifications.

5. PROCEDURES

The noise standards should be implemented at the earliest appropriate stage in the project development process. These procedures have been developed accordingly:

a. Project Development. A report on traffic noise will be required during the location planning stage and the project design stage. The reports may be sections in the location and design study reports, or they may be separate. The procedures for noise analysis, identification of solutions, coordination with local officials, and incorporation of noise abatement measures are as follows:

(1) Nonapplicable Projects. If a State highway department determines (in accordance with paragraph 4a that noise standards do not apply to a particular project, the requests for location approval and design approval shall contain statements to that effect, including the basis on which the State made its determination.

(2) Noise Analysis. For applicable projects, analyses of noise and evaluation of effects are to be made during project development studies using the following general steps:

(a) Predict the highway-generated noise level as described in the standards for each alternative under detailed study.

(b) Identify existing land uses or activities which may be affected by noise from the highway section.

(c) By measurement, determine the existing noise levels for developed land uses or activities.

(d) Compare the predicted noise levels with the design level values listed in the standards. Also compare the predicted noise levels with existing noise levels determined in paragraph 5a(2)(c). These comparisons will be the basis for determining the anticipated impact upon land uses and activities.

(e) Based upon the noise impacts determined in paragraph 5a(2)(d), evaluate alternative noise abatement measures for reducing or eliminating the noise impact for developed lands.

(f) Identify those situations where it appears that an exception to the design noise levels will be needed. Prepare recommendations to be included in the traffic noise report. (This report may be a portion of the location and design study reports or it may be a separate report.)

(3) Location Phase and Environmental Impact Statement Requirements. To the extent this PPM is applicable to the location phase of projects under paragraph 4, the noise report shall describe the noise problems which may be created and the plans for dealing with such problems for each alternative under detailed study. The level of detail of the noise analysis in the location phase should be consistent with the level of detail in which the location study itself is made. This information including a preliminary discussion of exceptions anticipated, shall be set forth in the location study report and summarized in the environmental impact statement (if one is prepared) and, as appropriate, at the location hearing (for location hearings after December 31, 1972). Studies and reports for highway locations approved before December 31, 1972, need not include an analysis and report on noise. In such instances, the noise analysis and report will be required only for the design approval.

(4) Design Phase Requirements. The noise analysis prepared for the location phase is to be updated and expanded using the refined alignment and design information developed during the design studies. The report on traffic noise will include a detailed analysis of the anticipated noise impact, alternative or proposed abatement measures, discussion of coordination with local officials, and recommended exceptions.

(5) Coordination with Local Officials on Undeveloped Lands. Highway agencies have the responsibility for taking measures that are prudent and feasible to assure that the location and design of highways are compatible with existing land use. Local governments, on the other hand, have responsibility for land development control and zoning. Highway agencies can be of considerable assistance to local officials in these efforts with a view toward promoting compatibility between land development and highways. Therefore, for undeveloped lands (or properties) highway agencies shall cooperate with local officials by furnishing approximate generalized future noise levels for various distances from the highway improvement, and shall make available information that may be useful to local communities to protect future land development from becoming incompatible with anticipated highway noise levels.

(6) Noise Abatement Measures for Lands Which are Undeveloped at Time of Location Approval

(a) Noise abatement measures are not required for lands which are undeveloped at the time of location approval; however, the highway agency may incorporate noise abatement measures for such undeveloped lands in the project design (if approved by FHWA) when a case can be made for doing so based on consideration of anticipated future land use, future need, expected long term benefits, and the difficulty and increased cost of later incorporating abatement measures.

(b) For land uses or activities which develop after location approval, noise abatement measures should be considered for incorporation in the project in the following situations:

1 It can be demonstrated that all practicable and prudent planning and design were exercised by the local government and the developer of the property to make the activity compatible with the predicted noise levels which were furnished to the local government and especially that a considerable amount of time has elapsed between location approval and highway construction

thus limiting local government's ability to maintain control over adjoining land uses.

2 The benefits to be derived from the use of highway funds to provide noise abatement measures is determined to outweigh the overall costs.

3 The noise abatement measures can be provided within the highway's proposed right-of-way or wider rights-of-way or easements acquired for that purpose.

(c) There are some situations where the design noise levels should be applied to lands which are undeveloped at the time of location approval. Some of these instances occur where the development of new land uses or activities is planned at the same time as the highway location studies. Other instances occur where planning for the new development has preceded the highway location studies but the development has been delayed. These types of situations should be treated as though the land use or activity were in existence at the time of location approval provided:

1 The State highway agency is apprised of such prior planning.

2 The construction of the new land use or activity is started prior to highway construction or there is good reason to believe that it will start before highway construction.

(7) Incorporation of Noise Abatement Measures in Plans and Specifications. For those projects to which the standards apply, the plans and specifications for the highway section shall incorporate noise abatement measures to attain the design noise levels in the standards, except where an exception has been granted.

(8) Requests for Exceptions. Requirements and supporting materials for requests for exceptions to the design noise levels are described in paragraph 2 of Appendix B to this PPM. To the extent possible, consistent with the level of detail of the location study, identifiable exceptions should be reported in the location study report. The request for location approval shall contain or be accompanied by a request for approval of exceptions that have been identified in the location stage. Supporting material may be contained in the location study report. Subsequent requests for review and approval of additional exceptions, if any, will be similarly processed in conjunction with design approval.

b. Federal Participation

(1) Shifts in alignment and grade are design measures which can be used to reduce noise impacts. The following noise abatement measures may also be incorporated in a project to reduce highway-generated noise impacts. The costs of such measures may be included in project costs.

(a) The acquisition of property rights (either in fee or a lesser interest) for providing buffer zones or for installation or construction of noise abatement barriers or devices.

(b) The installation or construction of noise barriers or devices, whether within the highway right-of-way or on an easement obtained for that purpose.

(2) In some specific cases there may be compelling reasons to consider measures to "sound-proof" structures. Situations of this kind may be considered on a case by case basis when they involve such public or non-profit institutional structures as schools, churches, libraries, hospitals, and auditoriums. Proposals of this type, together with the State's recommendation for approval, shall be submitted to FHWA for consideration.

c. Approval Authority

(1) Exceptions to the Design Noise Levels. The FHWA Division Engineer is authorized to approve exceptions to the design noise levels and alternate traffic characteristics for noise prediction as provided in paragraph 3b, Appendix B.

(2) Noise Prediction Method. Noise levels to be used in applying the noise standards shall be obtained from a prediction method approved by FHWA. The noise prediction method contained in National Cooperative Highway Research Program Report 117 and the method contained in Department of Transportation, Transportation Systems Center Report DOT-TSC-FHWA-72-1 are approved as of the date of this issue for use in applying the noise standards. Other noise prediction methods or variations of the above should be furnished to the FHWA Office of Environmental Policy together with supporting and validation information for approval.



R. R. Bartelsmeyer
Acting Federal Highway Administrator

DEFINITIONS (As used in this PPM)

Design Approval - the approval (described in PPM 20-8) given by the Federal Highway Administration (FHWA) (at the request of a State highway department) based upon a design study report and a design public hearing or opportunity therefor. This action establishes FHWA acceptance of a particular design and is prerequisite to authorization of right-of-way acquisition and construction.

Design Noise Level - the noise levels established by the noise standards set forth herein for various land uses or activities to be used for determining traffic noise impacts and the assessment of the need for and type of noise abatement treatment for a particular highway section.

Design Year - the future year used to estimate the probable traffic volume to be used as one of the primary bases for the roadway design. A time 20 years from construction is common for multilane and other major projects. Periods of 5 or 10 years are not uncommon for low volume roads.

Developed Land Uses or Activities - those tracts of land or portions thereof which contain improvements or activities devoted to frequent human use or habitation. The date of issue of a building permit (for improvements under construction or subsequently added) establishes the date of existence. Park lands in categories A and B of Table 1, Appendix B, include all such lands (public and private) which are actually used as parks on the date the highway location is approved and those public lands formally set aside or designated for such use by a governmental agency. Activities such as farming, mining, and logging are not considered developed activities. However, the associated residences could be considered as a developed portion of the tract.

Highway Section - a substantial length of highway between logical termini (major cross-roads, population centers, major traffic generators, or similar major highway control elements) as normally included in a single location study.

L₁₀ - the sound level that is exceeded 10 percent of the time (the 10th percentile) for the period under consideration. This value is an indicator of both the magnitude and frequency of occurrence of the loudest noise events.

Level of Service C - traffic conditions (used and described in the Highway Capacity Manual-Highway Research Board, Special Report 87) where speed and maneuverability are closely controlled by high volumes, and where vehicles are restricted in freedom to select speed, change lanes, or pass.

Location Approval - the approval (described in PPM 20-8) given by the FHWA (at the request of a State Highway Department) based upon a location study report and a corridor public hearing or opportunity therefor. This action establishes a particular location for a highway section and is prerequisite to authorization to proceed with the design. (Concurrent location and design approval is sometimes given for projects involving upgrading existing roads. In these instances, location approval is not a prerequisite to authorization of design.)

Noise Level - the weighted sound pressure level obtained by the use of a metering characteristic and weighting A as specified in American National Standard Specification S1.4-1971. The abbreviation herein used is dBA.

Operating Speed - the highest overall speed at which a driver can travel on a given highway under favorable weather conditions and under prevailing traffic conditions without at any time exceeding the safe speed as determined by the design speed on a section-by-section basis.

Project Development - studies, surveys, coordination, reviews, approvals, and other activities normally conducted during the location and design of a highway project.

Truck - a motor vehicle having a gross vehicle weight greater than 10,000 pounds and buses having a capacity exceeding 15 passengers.

NOISE STANDARDS

1. Design Noise Level/Land Use Relationship

a. The design noise levels in Table 1 (page B-4) are to be used during project development of a highway section to determine highway traffic noise impacts associated with different land uses or activities in existence at the time of location approval. In addition, the table is to be used to determine the need for abatement measures for traffic generated noise for developed land uses and activities in existence at the time of location approval. Exceptions to the design noise levels may be granted on certain types of highway improvements or portions thereof when the conditions outlined in paragraph 2 are met.

b. The exterior noise levels apply to outdoor areas which have regular human use and in which a lowered noise level would be of benefit. These design noise level values are to be applied at those points within the sphere of human activity (at approximate ear level height) where outdoor activities actually occur. The values do not apply to an entire tract upon which the activity is based, but only to that portion in which the activity occurs. The noise level values need not be applied to areas having limited human use or where lowered noise levels would produce little benefit. Such areas would include but not be limited to junkyards, industrial areas, railroad yards, parking lots, and storage yards.

c. The interior design noise level in Category E applies to indoor activities for those situations where no exterior noise sensitive land use or activity is identified. The interior design noise level in Category E may also be considered as a basis for noise abatement measures in special situations when, in the judgment of FHWA, such consideration is in the best public interest. In the absence of noise insulating values for specific structures, interior noise level predictions may be estimated from the predicted outdoor noise level by using the following noise reduction factors:

<u>Building Type</u>	<u>Window Condition</u>	<u>Noise Reduction Due to Exterior of the Structure.</u>	<u>Corresponding Highest Exterior Noise Level Which Would Achieve an Interior Design Noise Level of 55 dBA</u>
All	Open	10 dB	65 dBA
Light Frame	Ordinary Sash		
	Closed	20	75
	With Storm Windows	25	80
Masonry	Single Glazed	25	80
Masonry	Double Glazed	35	90

Noise reduction factors higher than those shown above may be used when field measurements of the structure in question indicate that a higher value is justified. In determining whether to use open or closed windows, the choice should be governed by the normal condition of the windows. That is, any building having year round air treatment should be treated as the closed window case. Buildings not having air conditioning in warm and hot climates and which have open windows a substantial amount of time should be treated as the open window case.

2. Exceptions

a. The design noise levels set out in these standards represent the highest desirable noise level conditions. State highway departments shall endeavor to meet the design noise levels in planning, locating, and designing highway improvements. However, there may be sections of highways where it would be impracticable to apply noise abatement measures. This could occur where abatement measures would not be feasible or effective due to physical conditions, where the costs of abatement measures are high in relation to the benefits achieved or where the measures required to abate the noise condition conflict with other important values, such as desirable esthetic quality, important ecological conditions, highway safety, or air quality.

b. A request for an exception to the design noise levels can be approved by the FHWA provided the highway agency has supported its request by a written summary report demonstrating that the following steps have been taken and outlining the results.

(1) Identified noise sensitive land uses along the section of highway in question which are expected to experience future highway traffic noise levels in excess of the design levels.

(2) Thoroughly considered all feasible measures that might be taken to correct or improve the noise condition.

(3) Weighed the costs or effects of the noise abatement measures considered against the benefits which can be achieved as well as against other conflicting values such as economic reasonableness, esthetic impact, air quality, highway safety, or other similar values, and thereby established that reduction of noise levels to desirable design levels is not in the best overall public interest for that particular highway section.

These decisions must ultimately be based upon case-by-case judgment. However, every effort should be made to obtain detailed information on the costs, benefits and effects involved to assure that final decisions are based on a systematic, consistent and rigorous assessment of the overall public interest.

(4) Considered lesser measures that could result in a significant reduction of noise levels though not to the design levels, and included such partial measures in the plans and specifications to the extent that they meet the test of economic reasonableness, practicability, and impact on other values, in the same manner as outlined in paragraph 2b(3).

c. In reviewing request for exception, the FHWA will give consideration to the type of highway and the width of the right-of-way. New freeway projects and most projects for the major reconstruction or upgrading of freeways allow for the use of noise control measures. Noise control measures are progressively more difficult to apply on other highways, particularly on local roads and streets because of numerous points of access, at-grade intersections, limited ability to acquire additional right-of-way as buffer zones, and the impossibility of altering roadway grades, constructing noise barriers and taking advantage of the terrain and other natural features.

d. Except in the most unusual situations, exceptions will be approved when the predicted traffic noise level from the highway improvement does not exceed the existing ambient noise level (originating from other sources) for the activity or land use in question.

3. Noise Level Predictions

a. Noise levels to be used in applying these standards shall be obtained from a predictive method approved by the FHWA. The predictive method and the noise level predictions should account for variations in traffic characteristics (volume, speed, and truck traffic), topography (vegetation, barriers, height, and distance), and roadway characteristics (configuration, pavement type, and grades). In predicting the noise levels, the following traffic characteristics shall be used:

(1) Automotive volume - the future volume (adjusted for truck traffic) obtained from the lesser of the design hourly volume or the maximum volume which can be handled under traffic level of service C conditions. For automobiles, level of service C is considered to be the combination of speed and volume which creates the worst noise conditions. For those highway sections where the design hourly volume or the level of service C condition is not anticipated to occur on a regular basis during the design year, the average hourly volume for the highest 3 hours on an average day for the design year may be used.

(2) Speed - the operating speed (as defined in the Highway Capacity Manual) which corresponds with the design year traffic volume selected in paragraph 3a(1) and the truck traffic predicted from paragraph 3a(3). The operating speed must be consistent with the volume used.

(3) Truck volume - the design hourly truck volume shall be used for those cases where either the design hourly volume or level of service C was used for the automobile volume.

Where the average hourly volume for the highest 3 hours on an average day was used for automobile traffic, comparable truck volumes should be used.

b. There are instances where activities associated with a particular land use (such as churches, schools, and resort hotels or residences) do not coincide with design hourly volumes. This may be particularly true when the design hourly volumes are seasonally oriented or where the activity associated with the land use is somewhat infrequent. There are other instances where changes in land use can be reasonably expected to occur before design year volumes are realized. In such instances, State highway agencies may request approval to compute noise predictions using traffic characteristics different from those specified in paragraph 3a. Such requests should be made on a project-by-project basis and should be accompanied by a justification.

TABLE 1
DESIGN NOISE LEVEL/LAND USE RELATIONSHIPS

Land Use Category	Design Noise Level - L ₁₀	Description of Land Use Category
A	60dBA (Exterior)	Tracts of lands in which serenity and quiet are of extraordinary significance and serve an important public need, and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose. Such areas could include amphitheaters, particular parks or portions of parks, or open spaces which are dedicated or recognized by appropriate local officials for activities requiring special qualities of serenity and quiet.
B	70 dBA (Exterior)	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals, picnic areas, recreation areas, playgrounds, active sports areas, and parks.
C	75 dBA (Exterior)	Developed lands, properties or activities not included in categories A and B above.
D	--	For requirements on undeveloped lands see paragraphs 5a(5) and (6), this PPM.
E*	55 dBA (Interior)	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals and auditoriums.

* See paragraph 1c of this Appendix for method of application.

APPENDIX B

DESCRIPTION OF ESL SOUND PROPAGATION MODEL

The generation and propagation of sound in the urban environment is a complicated phenomenon involving such factors as topography, meteorology, and traffic conditions. Topography includes roadway characteristics as well as those of the surrounding area; meteorology includes wind speed, wind direction, wind shear, and humidity; traffic conditions include percent of trucks and percent of cars in the traffic volume as well as speeds of each type of vehicle. A computer model was developed to address these complex factors. This model has been used in many studies throughout the country in evaluating and calculating sounds from transportation systems such as the regional noise analysis which was performed for the Interstate 66 corridor in Northern Virginia and Washington D.C. using this model.

Thus, in order to accurately calculate sound levels, the model separately addresses three aspects of urban sounds:

- the generation of airborne sound from various sources
- the propagation of sound in the atmosphere including the influence of meteorological conditions and local topographic features
- the statistical nature of these processes

The generation of sound from roadway vehicles depends on traffic conditions as well as roadway design. Increasing vehicle speeds or accelerating vehicles produce an increase in the generation of sound. The model calculates the variability of traffic and mean levels for each hour of the day. Statistical "clustering" and "voids" in spacing of vehicles is calculated for each hour. In addition, since trucks produce 15-25 dBA more sound than automobiles, the mix of trucks in the traffic stream is an important feature in determining sound levels. The model requires as input, the 24-hour average daily traffic (ADT) and this percent of traffic during each hour of the day as well as the traffic mix, (in percentage of trucks and cars) to address this phenomenon.

The propagation of sound in the atmosphere is governed by meteorological conditions as well as the presence of objects which can reflect, absorb,

or block sound in the atmosphere. Both roadside acoustic barriers and urban structures interfere with the propagation of sound in the atmosphere. Typical meteorological conditions for the Baltimore region as specified by the meteorological records at Baltimore-Washington International are used in the middle. The model calculates the influence of all these factors.

As discussed above, the PPM-90-2 criteria have applied to this noise analysis. The criteria require an evaluation of the levels exceeded 10 percent of the time; thus, it is necessary to address statistical fluctuations and mean values of the sound levels.

APPENDIX C

DIURNAL VARIATIONS IN COMMUNITY NOISE DOSAGE INSIDE BMATS

Table C-1 lists the diurnal variations for the jurisdictions inside BMATS. A column labeled "key" identifies the associated values. Key No. 1 is the average person hour noise dosage between the hours of 11 p.m. and 7 a.m. for each of the four categories. Key No. 2 describes the average person hour dosage for hours between 7 a.m. and 9 a.m. Key No. 3 represents hours 9 a.m. - 4 p.m. Key No. 4 represents 4 p.m. - 6 p.m. Key No. 5 represents 6 p.m. - 11 p.m. See Figures C-1 through C-4.

As can be seen, the heaviest noise dosage for all classes occurs during the day - Key Numbers 2, 3, and 4 or hours 7 a.m. - 6 p.m. This seems consistent with the higher traffic volumes during daytime hours and especially for the commercial and industrial, the higher population densities during the day. Under the residential class we note a slight variation to this trend. Along with higher dosages during the day, there are also high dosages in the evening. This seems consistent with the knowledge that people are generally at their residences in the evening, thus, the residential density is high during those hours. Along with the higher density are the moderate traffic volumes in the evening causing a larger residential noise dosage during those hours.

If measures are taken to control or improve the noise dosages, special attention should be placed on these hours; namely the daylight hours.

COMMUNITY DOSAGE INSIDE BMATS

JURISDICTION	KEY	RESIDENTIAL IMPACT	COMMERCIAL IMPACT	INSTITUTIONAL IMPACT	INDUSTRIAL IMPACT
BALTIMORE CITY					
ALT.1	1	17078.38	161.51	25.36	0.0
	2	10786.05	36079.91	9834.09	6026.29
	3	5545.81	59881.50	13126.43	10928.05
	4	7046.19	58721.31	12636.92	10546.93
	5	20778.56	376.11	42.37	1853.08
	6	314946.50	611819.06	137222.06	118897.56
	7	904896.00	368359.00	102534.00	67831.00
ANNE ARUNDEL COUNTY					
ALT.1	1	164.48	14.83	0.95	0.0
	2	92.69	2901.98	288.98	1273.07
	3	47.57	4789.98	385.98	2308.73
	4	61.08	4756.60	378.99	2276.02
	5	194.10	32.83	1.44	447.84
	6	2926.53	49125.82	4052.42	25496.57
	7	195366.00	97169.00	15586.00	13069.00
BALTIMORE COUNTY					
ALT.1	1	608.74	17.23	7.17	0.0
	2	362.31	3706.72	3061.93	2997.69
	3	185.79	6151.71	4078.13	5453.16
	4	236.90	6034.94	3951.49	5286.52
	5	726.52	39.12	13.02	955.82
	6	11000.33	62874.79	42693.28	59516.30
	7	612080.00	219478.00	65908.00	42841.00
HOWARD COUNTY					
ALT.1	1	0.75	0.08	0.27	0.0
	2	0.40	15.13	98.26	13.84
	3	0.21	25.24	132.04	25.27
	4	0.26	25.40	129.96	24.68
	5	0.83	0.18	0.44	4.57
	6	12.92	259.32	1385.07	276.79
	7	53753.00	24538.00	4904.00	2572.00
BALTIMORE CITY					
ALT.3	1	16499.50	184.50	33.52	0.0
	2	10526.60	41072.03	12268.91	7054.50
	3	5396.77	68076.00	16367.40	12812.60
	4	6667.84	66847.13	15777.71	12403.06
	5	20170.60	427.23	53.80	2233.97
	6	375363.94	695813.88	171181.06	139761.31
	7	879791.00	354056.00	104701.00	67302.00
ANNE ARUNDEL COUNTY					
ALT.3	1	344.99	22.09	1.05	0.0
	2	187.91	4229.44	326.64	1438.69
	3	96.56	6996.51	434.01	2611.21
	4	124.43	6965.26	430.67	2584.38
	5	397.28	47.85	1.70	509.97
	6	6046.30	71773.63	4569.46	28872.60
	7	257973.00	135916.00	16214.00	14208.00
BALTIMORE COUNTY					
ALT.3	1	1232.54	26.09	10.97	0.0
	2	700.23	5365.05	4182.94	3672.77
	3	359.35	8911.33	5594.90	6673.59
	4	459.25	8779.78	5452.11	6514.52
	5	1436.85	58.26	18.90	1232.67
	6	21877.06	91159.50	58613.39	73248.69
	7	729760.00	282579.00	72262.00	45082.00
HOWARD COUNTY					
ALT.3	1	1.89	0.10	4.65	0.0
	2	0.98	19.91	1465.58	45.20
	3	0.51	33.02	1954.54	81.08
	4	0.65	33.26	1957.40	82.36
	5	2.10	0.23	7.77	16.56
	6	32.48	339.47	20602.30	905.43
	7	154660.00	79077.00	18855.00	6978.00

NOTE:

- Key 1: 11 p.m. to 7 a.m. person-hours dosage
 2: 7 a.m. to 9 a.m. person-hours dosage
 3: 9 a.m. to 4 p.m. person-hours dosage
 4: 4 p.m. to 6 p.m. person-hours dosage
 5: 6 p.m. to 11 p.m. person-hours dosage
 6: 24-hour person-hours dosage
 7: Internal computer code

TABLE C-1. DIURNAL VARIATION IN COMMUNITY DOSAGE INSIDE
 BMATS (PART 1 OF 4)

BALTIMORE CITY					
ALT.4	1	16491.39	839.62	31.52	0.0
	2	10478.94	202397.56	11634.44	6811.21
	3	5374.76	336402.69	15569.61	12370.95
	4	6844.35	329042.06	14947.32	11980.61
	5	20237.19	2029.08	50.72	2151.23
	6	30533.75	3433163.00	162635.38	134924.63
	7	676992.00	1104194.00	103660.00	66945.00
ANNE ARUNDEL COUNTY					
ALT.4	1	354.13	22.24	1.06	0.0
	2	193.05	4264.93	332.40	1470.36
	3	99.27	7048.07	434.03	2654.13
	4	128.37	7017.86	438.88	2635.70
	5	408.83	48.22	1.70	519.58
	6	6214.39	72313.63	4597.57	29387.00
	7	260737.00	136010.00	16249.00	14348.00
BALTIMORE COUNTY					
ALT.4	1	1217.69	26.29	11.14	0.0
	2	689.99	5389.81	4219.46	3708.79
	3	354.43	8951.25	5618.09	6735.84
	4	452.84	8817.79	5498.90	6576.46
	5	1416.62	58.48	19.12	1247.16
	6	21589.51	91567.00	58944.99	73952.75
	7	723576.00	282691.00	72346.00	45343.00
HOWARD COUNTY					
ALT.4	1	1.89	0.10	4.66	0.0
	2	0.98	20.16	1468.15	47.03
	3	0.51	33.42	1958.09	85.48
	4	0.65	33.52	1982.44	85.38
	5	2.10	0.23	7.79	17.50
	6	32.45	343.28	20682.53	950.64
	7	154525.00	79093.00	18905.00	7015.00
BALTIMORE CITY					
ALT.5	1	15732.16	159.08	29.01	0.0
	2	9734.82	35045.06	10704.94	6194.09
	3	4885.17	58108.08	14281.08	11167.52
	4	6357.16	57154.72	13752.07	10799.85
	5	19227.92	371.58	46.84	1928.90
	6	289026.63	594182.56	149332.00	121714.06
	7	851644.00	341827.00	101692.00	64939.00
ANNE ARUNDEL COUNTY					
ALT.5	1	375.67	22.13	1.09	0.0
	2	203.96	4222.34	338.61	1573.64
	3	104.88	6980.57	449.06	2849.70
	4	135.45	6935.27	447.58	2818.78
	5	432.76	47.86	1.76	558.63
	6	6581.60	71588.19	4733.23	31523.59
	7	266369.00	134972.00	16419.00	15148.00
BALTIMORE COUNTY					
ALT.5	1	1230.73	25.58	11.37	0.0
	2	697.27	5227.96	4266.43	3811.08
	3	357.45	8681.06	5704.58	6930.91
	4	456.85	8557.02	5567.66	6767.29
	5	1429.92	56.82	19.50	1281.87
	6	21803.84	88817.00	59785.43	76077.50
	7	726376.00	276175.00	72704.00	46681.00
HOWARD COUNTY					
ALT.5	1	1.90	0.10	4.82	0.0
	2	0.99	19.81	1503.90	50.77
	3	0.51	32.85	2006.67	90.84
	4	0.66	33.10	2030.70	92.42
	5	2.12	0.23	7.94	18.93
	6	32.74	337.74	21192.79	1016.90
	7	152874.00	76813.00	19365.00	7400.00

NOTE:

- Key
- 1: 11 p.m. to 7 a.m. person-hours dosage
 - 2: 7 a.m. to 9 a.m. person-hours dosage
 - 3: 9 a.m. to 4 p.m. person-hours dosage
 - 4: 4 p.m. to 6 p.m. person-hours dosage
 - 5: 6 p.m. to 11 p.m. person-hours dosage
 - 6: 24-hour person-hours dosage
 - 7: Internal computer code

TABLE C-1. DIURNAL VARIATION IN COMMUNITY DOSAGE INSIDE
BMATS (PART 2 OF 4)

BALTIMORE CITY						
ALT. 6	1	16893.55	230.21	37.96	0.0	
	2	10639.38	50503.22	13839.16	8682.65	
	3	5447.65	83798.06	18446.88	15757.38	
	4	6947.60	82239.19	17789.47	15262.76	
	5	20604.76	529.26	60.51	2755.24	
	6	311437.69	856358.00	192970.13	171954.94	
	7	906286.00	429632.00	115194.00	78173.00	
ANNE ARUNDEL COUNTY						
ALT. 6	1	733.59	26.69	2.13	0.0	
	2	394.54	5217.25	615.91	2742.98	
	3	202.13	8592.11	823.21	4942.71	
	4	263.60	8616.94	808.44	4922.22	
	5	844.23	58.28	3.15	989.27	
	6	12820.49	88309.75	8643.18	54872.31	
	7	371656.00	170049.00	19961.00	22252.00	
BALTIMORE COUNTY						
ALT. 6	1	2521.17	37.03	14.30	0.0	
	2	1450.57	7542.66	5272.48	7033.19	
	3	747.94	12544.08	7059.41	12826.86	
	4	954.86	12369.49	6897.35	12534.75	
	5	2953.17	82.25	24.12	2385.38	
	6	44977.24	128325.75	73986.75	140841.50	
	7	908557.00	342507.00	81243.00	62797.00	
HOWARD COUNTY						
ALT. 6	1	4.91	0.13	5.75	0.0	
	2	2.54	26.38	1990.04	245.63	
	3	1.32	44.06	2668.03	448.35	
	4	1.70	43.76	2639.85	440.96	
	5	5.46	0.29	9.27	88.86	
	6	84.31	451.16	28026.70	4955.79	
	7	271744.00	96851.00	29051.00	12850.00	
BALTIMORE CITY						
ALT. 7	1	15346.01	192.49	31.93	0.0	
	2	9385.24	42172.84	11699.84	7344.68	
	3	4812.70	69981.75	15607.45	13322.60	
	4	6137.26	68677.75	15076.66	12931.86	
	5	18667.94	446.13	50.58	2300.52	
	6	280804.25	715176.38	163292.75	145301.56	
	7	660593.00	405554.00	107714.00	73253.00	
ANNE ARUNDEL COUNTY						
ALT. 7	1	676.19	26.08	2.13	0.0	
	2	363.79	5042.47	619.22	2805.59	
	3	186.41	8354.31	825.73	5100.33	
	4	242.76	8351.74	810.14	5055.69	
	5	777.40	56.70	3.11	1019.73	
	6	11813.99	85752.44	8670.44	56520.21	
	7	365718.00	158141.00	20909.00	23434.00	
BALTIMORE COUNTY						
ALT. 7	1	2291.78	36.48	14.78	0.0	
	2	1324.32	7418.48	5379.23	7236.02	
	3	682.81	12333.17	7222.09	13204.93	
	4	871.78	12168.55	7013.96	12898.73	
	5	2690.68	81.02	24.99	2460.46	
	6	40955.18	126189.00	75579.75	144997.19	
	7	874704.00	340298.00	82162.00	65939.00	
HOWARD COUNTY						
ALT. 7	1	4.79	0.12	6.23	0.0	
	2	2.49	26.04	2127.19	274.45	
	3	1.29	43.49	2846.70	500.99	
	4	1.67	43.15	2833.11	490.27	
	5	5.33	0.29	9.89	99.06	
	6	82.37	445.26	29945.05	5531.50	
	7	262828.00	93819.00	30201.00	13403.00	

NOTE:

- Key 1: 11 p.m. to 7 a.m. person-hours dosage
2: 7 a.m. to 9 a.m. person-hours dosage
3: 9 a.m. to 4 p.m. person-hours dosage
4: 4 p.m. to 6 p.m. person-hours dosage
5: 6 p.m. to 11 p.m. person-hours dosage
6: 24-hour person-hours dosage
7: Internal computer code

TABLE C-1. DIURNAL VARIATION IN COMMUNITY DOSAGE INSIDE
BMATS (PART 3 OF 4)

BALTIMORE CITY ALT.8	1	21384.13	231.43	40.33	0.0
	2	12996.70	49672.97	14331.68	9124.59
	3	6637.72	82251.63	19081.31	16535.30
	4	8484.29	81053.06	18451.69	16055.51
	5	25892.66	532.03	63.74	2931.59
	6	389893.75	841518.50	199754.19	180751.13
	7	1031806.00	422027.00	116881.00	80786.00
ANNE ARUNDEL COUNTY ALT.8	1	432.40	24.81	1.40	0.0
	2	234.98	4769.26	420.63	1924.90
	3	120.03	7882.47	558.92	3457.67
	4	154.11	7807.99	549.44	3409.99
	5	504.12	53.95	2.11	670.18
	6	7597.64	80793.38	5874.22	38221.65
	7	313726.00	156451.00	19040.00	20733.00
BALTIMORE COUNTY ALT.8	1	1890.58	30.08	12.90	0.0
	2	1054.15	6046.40	4827.85	4669.45
	3	540.02	10035.81	6423.58	8451.28
	4	691.20	9905.90	6286.90	8263.18
	5	2179.54	66.45	21.89	1561.97
	6	33290.39	102717.44	67403.94	92827.44
	7	826899.00	326265.00	79520.00	56284.00
HOWARD COUNTY ALT.8	1	3.60	0.12	3.48	0.0
	2	1.86	24.27	1316.41	132.21
	3	0.95	40.59	1706.89	244.85
	4	1.22	39.91	1751.19	238.13
	5	4.01	0.27	5.96	47.16
	6	61.67	414.79	18140.00	2693.84
	7	235840.00	93420.00	28720.00	10959.00
BALTIMORE CITY ALT.9	1	19125.64	196.90	33.52	0.0
	2	11371.06	42136.72	12047.57	7537.24
	3	5806.54	69722.69	16017.07	13615.95
	4	7441.07	68893.50	15492.57	13231.98
	5	23119.13	455.04	53.70	2389.89
	6	346809.94	713791.38	167714.88	148786.69
	7	978208.00	405737.00	108709.00	74845.00
ANNE ARUNDEL COUNTY ALT.9	1	406.39	23.13	1.40	0.0
	2	220.68	4476.80	425.56	1882.58
	3	112.76	7393.09	564.70	3416.41
	4	144.87	7318.95	557.19	3369.20
	5	474.82	50.55	2.14	666.22
	6	7145.17	75774.44	5940.15	37746.76
	7	300165.00	152448.00	19599.00	19253.00
BALTIMORE COUNTY ALT.9	1	1654.19	28.73	12.82	0.0
	2	925.95	5798.46	4736.94	4645.75
	3	474.31	9618.41	6345.30	8434.43
	4	606.69	9496.55	6190.94	8240.13
	5	1916.75	63.72	21.79	1568.79
	6	29200.27	98457.25	66481.13	92650.13
	7	791041.00	317523.00	79493.00	57405.00
HOWARD COUNTY ALT.9	1	3.36	0.12	3.44	0.0
	2	1.75	23.49	1286.55	132.14
	3	0.90	39.28	1686.35	241.46
	4	1.16	38.70	1692.36	234.79
	5	3.78	0.26	5.75	46.78
	6	57.97	401.57	17817.48	2657.96
	7	234481.00	90013.00	29824.00	11144.00

NOTE:

- Key
- 1: 11 p.m. to 7 a.m. person-hours dosage
 - 2: 7 a.m. to 9 a.m. person-hours dosage
 - 3: 9 a.m. to 4 p.m. person-hours dosage
 - 4: 4 p.m. to 6 p.m. person-hours dosage
 - 5: 6 p.m. to 11 p.m. person-hours dosage
 - 6: 24-hour person-hours dosage
 - 7: Internal computer code

TABLE C-1. DIURNAL VARIATION IN COMMUNITY DOSAGE INSIDE
BMATS (PART 4 OF 4)

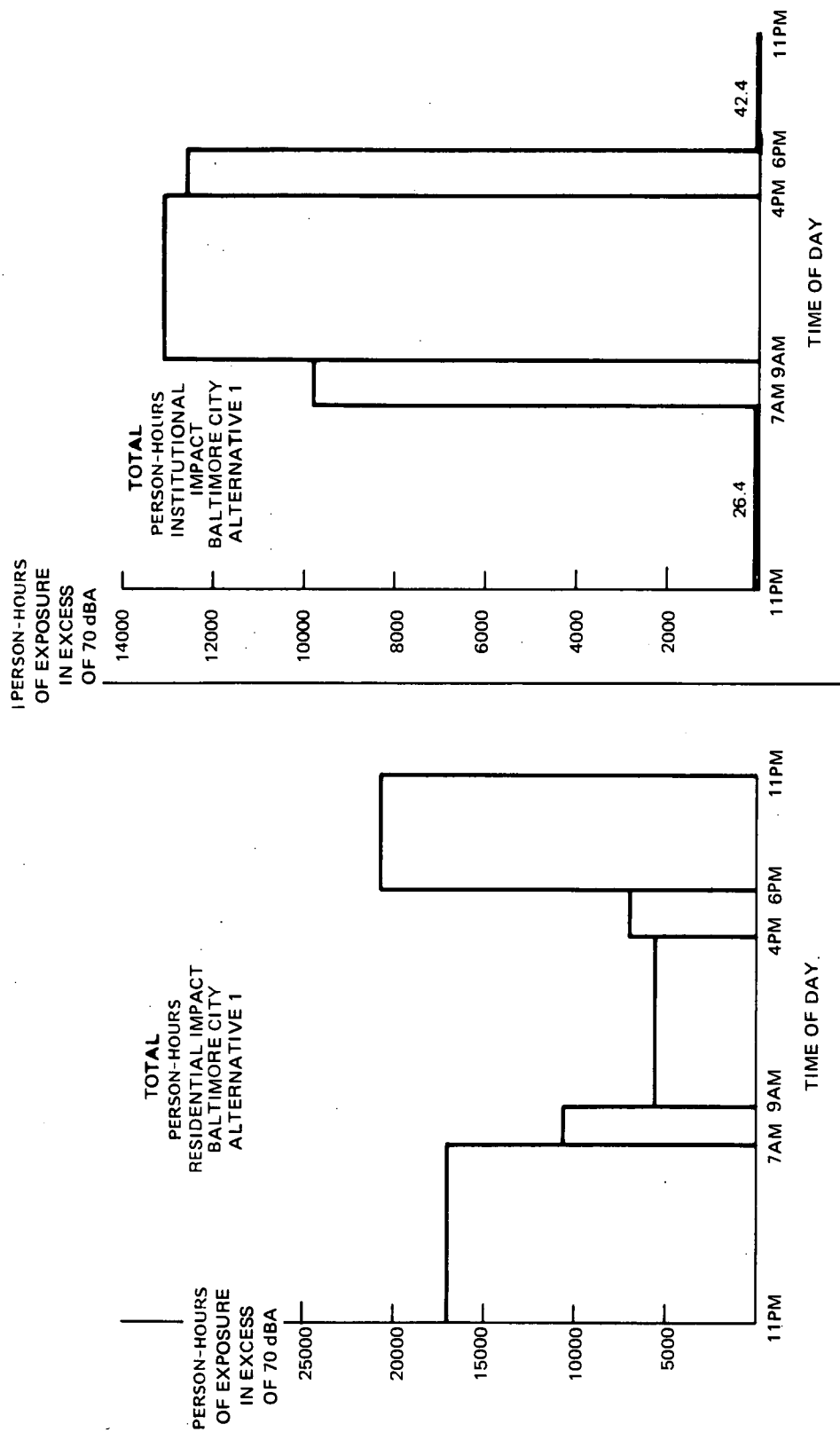


FIGURE C-1 DIURNAL COMMUNITY DOSAGE INSIDE BMATS: BALTIMORE CITY

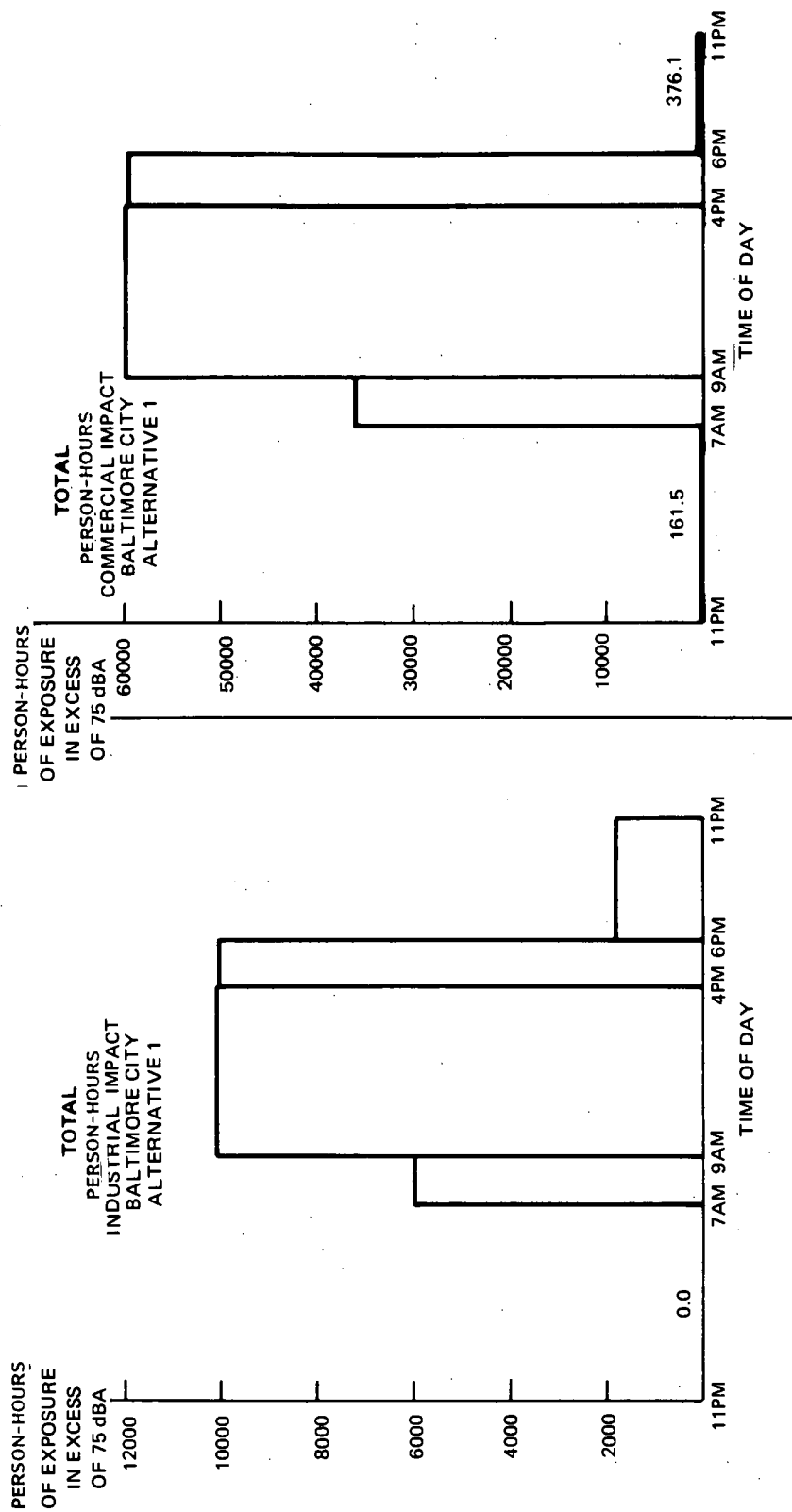


FIGURE C-2. DIURNAL COMMUNITY DOSAGE INSIDE BMATs: BALTIMORE CITY

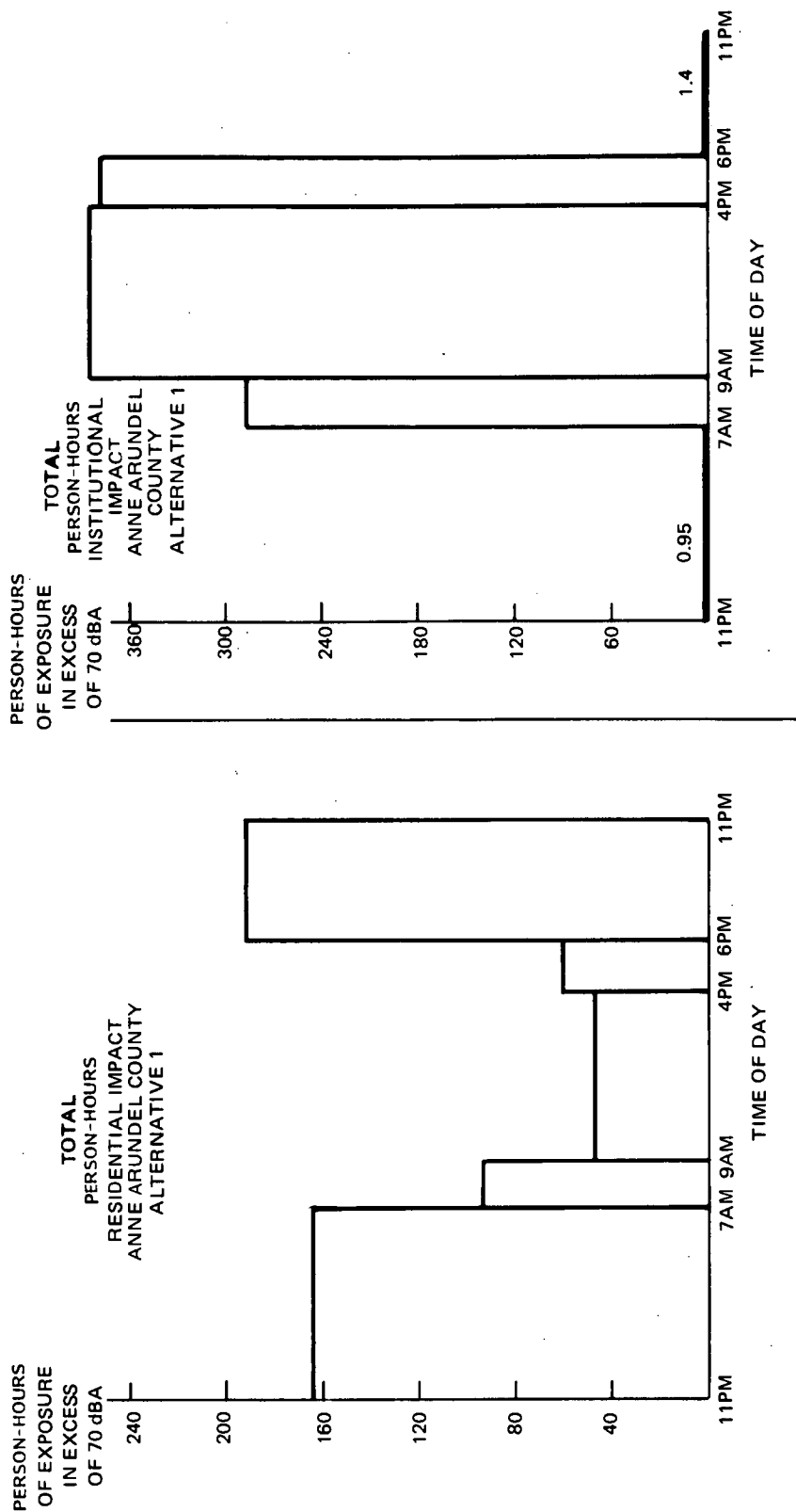


FIGURE C-3. DIURNAL COMMUNITY DOSAGE INSIDE BMATS: ANNE ARUNDEL COUNTY

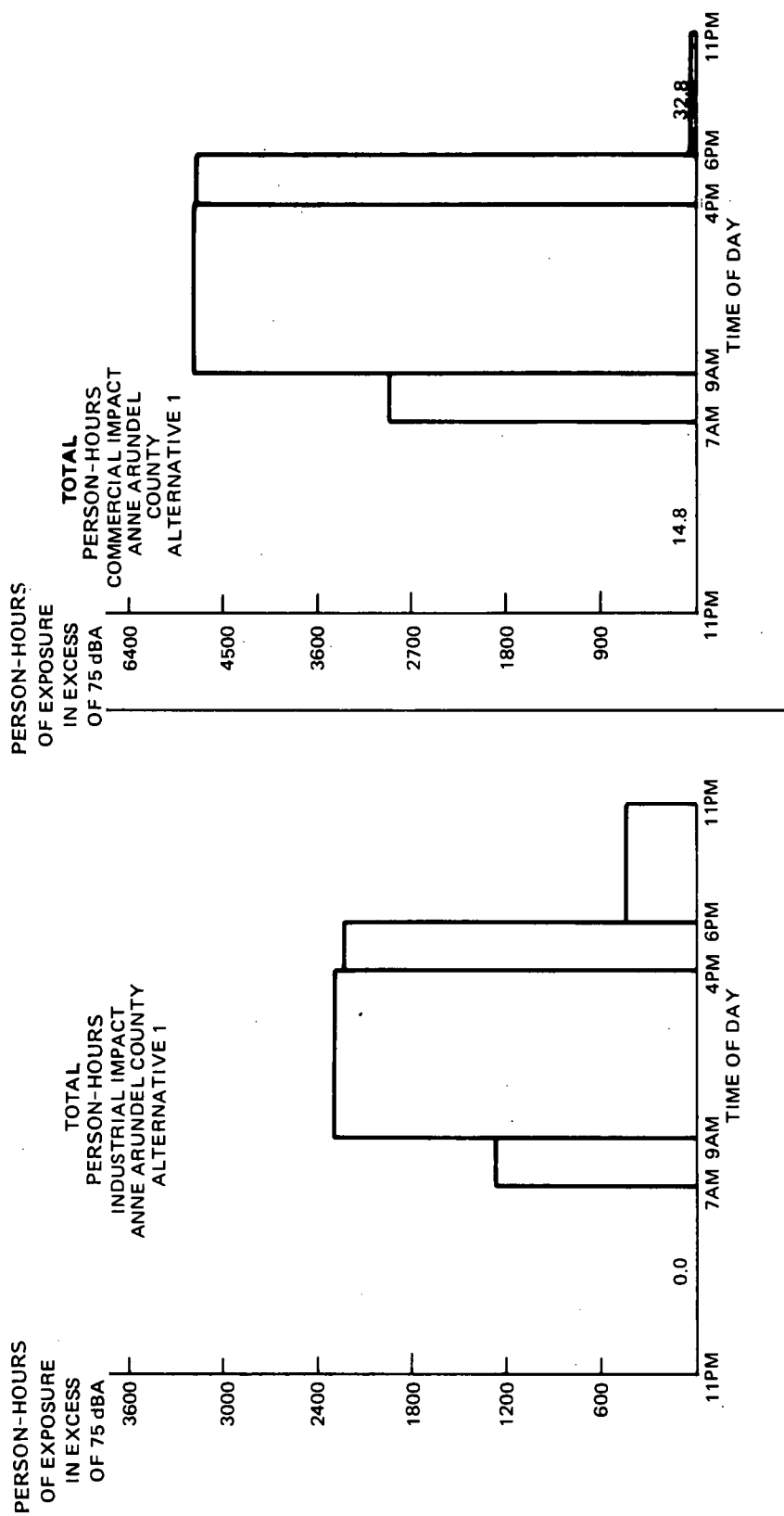


FIGURE C-4. DIURNAL COMMUNITY DOSAGE INSIDE BMATS: ANNE ARUNDEL COUNTY

APPENDIX D

INPUTS FOR NOISE ANALYSIS

The noise analysis modelling procedure required several data items in addition to the socioeconomic data (population, employment, etc.) reported in the technical memorandum on Socioeconomic and Land Use data. These requirements for each alternative were as follows:

- Traffic data
- Miles of streets by RPD
- Miles of road on the RPD networks by RPD
- VMT on the network
- VMT on local streets
- Bus trip ends at the rapid transit stations

Traffic Data

A system of data analysis programs was created in order to determine air quality and noise pollution for the alternative networks for the Baltimore region. Figure D-1 contains the system flow of data from the final capacity network output to the link data summaries by regional planning district (RPD) and link classification.

Rather than modify the existing pollution modelling programs to accept the Bureau of Public Roads (BPR) formatted network tapes, it was determined that existing computer programs could be utilized. The first of these programs was ANALHR. This program extracted only the necessary data used later by the various pollution models and link summary programs. The program eliminated the duplication of link data inherited by the BPR network and formatted the data so that it was easily understandable. The second program used was NETGEN which produced data that was input to both the air and noise models and link summaries. Table D-1 contains the information of the data record used for link summaries and noise pollution analysis. For the SRI air pollution model, link data information was punched on cards for further processing. Only the primary routes and freeways were considered because of the limitations of the SRI model. There were three user subroutines compiled with NETGEN. These subroutines contained different environmental emission factors for each design year and were used in the CO emissions model.

The last data analyzing program executed was the AVADDR program. This program will summarize the various link attributes shown in Table D-1..

Miles of Streets

It was not feasible to measure the length of all streets in the region in 1970 or predict in detail the construction of additional local streets for each alternative. A sampling procedure was therefore adopted. Five classes of street density were chosen to represent the block spacing and subsequently miles of street for a given area. The 1970 road mileage was measured in several traffic zones in each category and divided by the total average to obtain street densities.

Not all zones are fully developed for street use. To account for anomalies such as large golf courses, parks, cemeteries, etc., each traffic zone was assigned the percentage it was developed into streets at a given density. For 1970 the road mileage in any zone was equal to the product of its percentage developed into street use, its street density, and its area. The zonal street mileage was aggregated to RPD level for the noise analysis in 1970.

For each alternative in the future, street mileage was considered a function of population. Future mileage was calculated for each RPD as the 1970 mileage plus .003 times the net increase in population. Where there was a decrease in population road mileage was maintained at its 1970 level to account for conversion of residential land to other use. No RPD was allowed to exceed the maximum road densities found in Baltimore City Fringe in 1970. One RPD, Columbia, which had an extremely large population increase, had to be adjusted by hand.

As an independent check, national figures were obtained. In 1971 there were 593,047 miles of urban streets in the United States (Ref. 1) with a population of 208,90,000 people, of whom 65,000,000 were rural residents (extrapolated from the 1970 census in which there were 63,793,000 rural residents). This is approximately .00412 miles of urban street per urban resident. The lower figure (.003 miles per capita) used in our study applies only to net increase and allows for the present infrastructure.

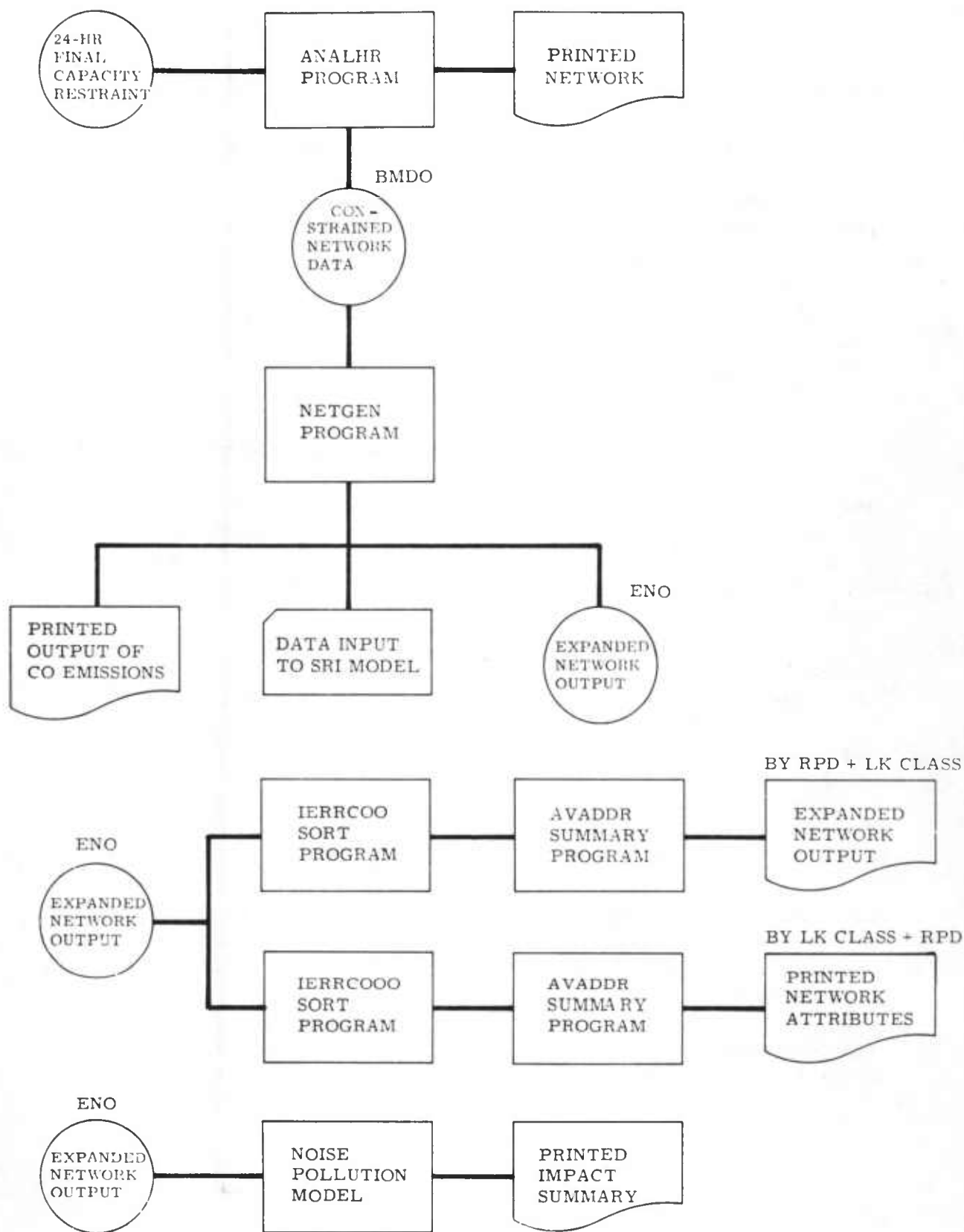


FIGURE D-1

SYSTEM FLOW FOR CONVERSION OF TRAFFIC DATA
FOR AIR AND NOISE ANALYSIS

Table D-1

(INPUT TO NOISE AND AIR POLLUTION MODELS)
OUTPUT OF NETGEN

Data Record								
Item	Cols.	Contents	Item	Columns	Contents			
1	1- 8	A-Node	26	201-208	X-COORDINATE - A NODE			
2	9- 16	B-Node	27	209-216	Y-COORDINATE - A NODE			
3	17- 24	Administration Class *	28	217-224	VMT-AUTO PEAK (Non-Directional)			
4	25- 32	Functional Class **	29	225-232	VMT-HDV PEAK			
5	33- 40	Adjacent Land Use ***	30	233-240	VMT-LDV PEAK			
6	41- 48	Link Location (RPD)	31	241-248	VHR-AUTO PEAK			
7	49- 56	Route Number	32	249-256	VHR-HDV PEAK			
8	57- 64	Hourly Capacity (Service C A-B)	33	257-264	VHR LDV PEAK			
9	65- 72	Hourly Capacity (Service C B-A)	34	265-272	VMT-AUTO 24HR			
10	73- 80	Width A-B Ft.	35	273-280	VMT-HDV 24HR			
11	81- 88	Width B-A Ft.	36	281-288	VMT-LDV 24HR			
12	89- 96	Speed (Level C) (10's)	37	289-296	VMT-AUTO 24HR			
13	97-104	Dist A-B Link Length (100's)	38	297-304	VMT-HDV 24HR			
14	105-112	HDV-ADT (A-B) 24 Hr.	39	305-312	VMT-LDV 24HR			
15	113-120	HDV-ADT (B-A) 24 Hr.	40	313-320	AVE-PEAK SPEED A-B			
16	121-128	LDV-ADT (A-B) 24 Hr.	41	321-328	AVE-PEAK SPEED B-A			
17	129-136	LDV-ADT (B-A) 24 Hr.	42	329-336	AVE-24HR SPEED A-B			
18	137-144	Auto-ADT (A-B) 24 Hr.	43	337-344	AVE-24HR SPEED B-A			
19	145-152	Auto-ADT (B-A) 24 Hr.	44	345-352	X-COORDINATE-B NODE			
20	153-160	HDV-ADT (A-B) PP	45	353-360	Y-COORDINATE-B NODE			
21	161-168	HDV-ADT (B-A) PP						
22	169-176	LDV-ADT (A-B) PP						
23	177-184	LDV-ADT (B-A) PP						
24	185-192	Auto-ADT (A-B) PP						
25	193-200	Auto-ADT (B-A) PP						
						** 1 = Freeway *** 10 = High CBD		
						2 = Major Arterial 20 = Medium Fringe		
						3 = Minor Arterial 30 = Outlying Business		
						4 = Collectors 40 = Rural		
						5 = Off Ramps		
						6 = On Ramps		
						9 = Centroid Connectors		
						* 1 = Toll		
						2 = Interstate		
						3 = State Primary		
						4 = State Secondary		
						5 = Local		

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networks and punched as input to the noise analysis. If 24-hour bus trips are desired, a factor of 10 can be used since 10.4 percent of daily bus seat miles are driven in the one-hour peak (Ref. 2).

REFERENCES

1. U.S. Department of Transportation, 1971 Highway Statistics.
2. Bob Prangle, Baltimore Transit Commissioner, telephone conversation with A.M. Lacey, Alan M. Voorhees & Associates, July, 1973.

APPENDIX E

GENERAL DISCUSSION OF ROADWAY BACKGROUND NOISE LEVELS

In any urban or rural area, the local traffic is often a significant contributor to the background noise. This background noise level can be calculated in terms of the daily vehicle miles of travel (VMT) per miles of streets (MS). The 24-hour mean traffic (t) on the street system is given by the following relationship:

$$t = \frac{\text{VMT}}{\text{MS}}$$

The mean traffic (T(H)) during any one hour (H) is given by the percent (P(H)) of the 24-hour mean traffic which occurs during each particular hour.

$$T(H) = P(H) \times t = P(H) \times \frac{\text{VMT}}{\text{MS}}$$

Thus, if a typical residential dwelling is assumed to be a distance, d, from a road, then the expected L_{10} dBA noise level can be calculated:

$$L_{10} = N(T(H), d, S)$$

Where:

N is the function describing the noise level
detected at distance (d) from a street with volume T(H)
with traffic moving at some typical speed (S).

Figure A-1 describes this relationship. For two areas with the same number of street miles per acre but different densities, the noise levels are related directly to the density, assuming the VMT is proportional to the density. Thus, in an area which has twice the density as the other, but identical street miles, the background noise level will be approximately 3dBA greater in the denser region (i.e., there are twice as many sources).

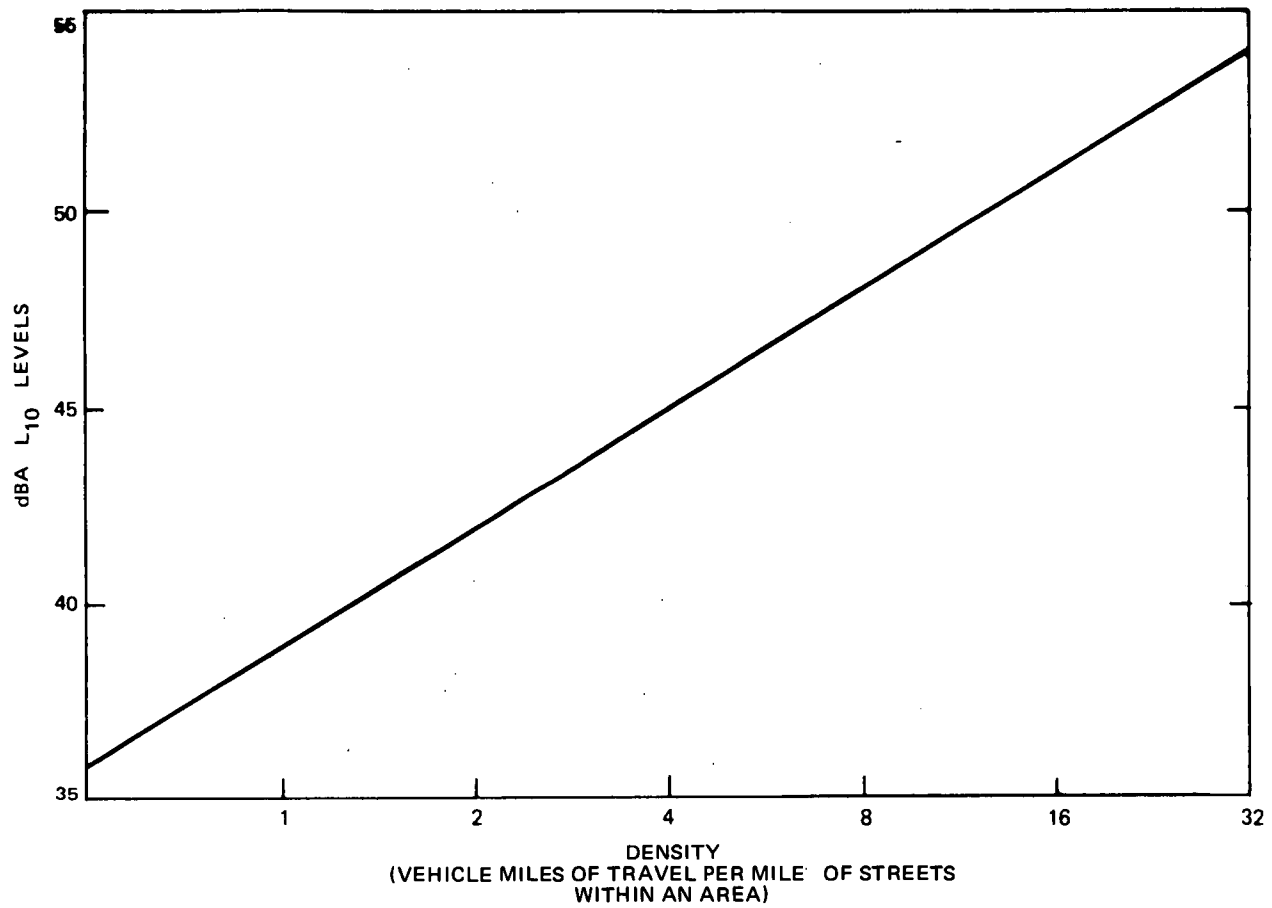


FIGURE E-1. BACKGROUND L_{10} dBA LEVELS A FIXED DISTANCE FROM A TYPICAL STREET

